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NAYAR, K. K., M. BALLS & E. ARTHUR (1970) Transmission of amphibian lymphosarcoma to and through insects. *Oncology*, **24**: 370–377.

Books: NAYAR, K.K. (1973) *Elements in Insect Endocrinology*. Prentice Hall, India, 56pp. *Chapter in a book compiled and edited*: GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 249–370, *in: The Physiology of Insecta*, Vol. **1**, 2nd ed. (ed. ROCKSTEIN, M.), Academic Press, New York & London.

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EDITORIAL NOTE

Entomon is now three years old and has grown into a Quarterly. In its fourth year it looks back with mixed feelings of humility and pride and looks forward with confidence. It thanks the past Editorial Board which contributed to its present growth, and it is a pleasure that the former Editors of the journal will continue to remain associated with it : TNA, NCP and KNS are continuing in the Editorial Advisory Board; their sagacity and immense experiense will be available to the new Editorial Board. NRP MRGKN and DNR are in the present Editorial Board and VKKP will continue to be the Managing Editor. It is hoped that KJJ and GKK also will join the new Editorial Board after their overseas assignment. It welcomes the new members of the Board and hopes that the new team will pave the way for its continued growth.

Managing Editor

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AUTORADIOGRAPHIC STUDIES ON RNA SYNTHESIS IN TROPHOCYTES AND GERMINAL VESICLE OF *MENOCHILUS SEXMACULATUS* F. (COLEOPTERA, COCCINELLIDAE)

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Tracer studies with ^{3}H-uridine in *Menochilus sexmaculatus* showed that nurse cells synthesise amounts of RNA in the nuclei and supply it to developing oocytes during their growth. Apart from this the germinal vesicle also incorporates tritiated uridine at least in previtellogenic oocytes which ultimately ceases in vitellogenic stages. These results suggest that there are two clear sources of RNA which are utilised during the euplasmic growth of oocytes - one from the nurse cells and other from the germinal vesicles.

(*Key words* : *Menochilus sexmaculatus*, **radioautography, nurse cells, oocytes, germinal vesicle, RNA synthesis)**

INTRODUCTION

In regard to RNA metabolism in insect ovaries there is consensus among the workers that the trophic tissue in the germarium of the meroistic ovarioles is the main center of RNA synthesis and this is supplied to the oocytes for their euplasmic growth, via fusomes in polytrophic ovaries or the trophic cords in the telotrophic ovaries (TELER, 1965 ; MAHOWALD, 1972). Existing evidence in regard to the RNA synthetic role of germinal vesicle (GV) and its export to the oocytes is contradictory (ZALOKAR, 1960 ; FAVARD-SERENO, & DURAND, 1963 ; KUNZ, 1967), while in polytrophic ovaries of *Panorpa communis* (RAMAMURTY, 1963), GV is quiescent. The situation in telotrophic ovaries is not fully understood yet, though there are reports that GV has no role in RNA synthesis (VANDERBERG, 1954 ; MACGREGOR & STEBBINGS, 1970). It is, therefore, necessary to clarify this problem in the telotrophic ovaries of species investigated here by autoradiographic methods.

MATERIALS AND METHODS

For the present study *Menochilus sexmaculatus* has been collected from brinjal fields during the months of December to March. It feeds during the larval and adult stages on aphids infesting this crop. It could be maintained in the laboratory for acclimatization over a period of 1–2 weeks, feeding them on aphids.

For autoradiograhic study, ^{3}H-uridine (Specific activity, 9.7 Ci/mM) has been used as precursor for RNA. The labelled compound was injected (1 μCi/20 mg body wt) into the haemocoel by means of glass needles and incubated for periods ranging from 15 min to 6 h. Ovaries were fixed at the end of the incubation period in Carnoy's fluid. 7μm thick sections were treated with 5% trichloracetic acid at 4°C for 15 min and then processed for autoradiography, using K2 Ilford Emulsion. These slides were exposed for 5 weeks in dark and then developed in Kodak D 19 B developer and mounted in Euparal.

OBSERVATIONS

In this species the egg maturation occurs in four different stages. Stages I and II are previtellogenic, stage III is active vitellogenic and stage IV is postvitellogenic.

In stages I and II the growth of the oocyte is mainly euplasmic, whereas in stage III it is due to accumulation of the yolk droplets; lastly in stage IV the vitelline membrane and chorion are laid down.

In autoradiograms, 15 min (Fig. 1) and 30 min incubation with H^3-uridine results in a moderate labelling of the trophocyte nuclei, which are the well-known centers of RNA synthesis. With 1 h incubation, the pattern remains more or less same but it undergoes intensification (Fig. 2). With 2 h incubation one observes the movement of radioactivity from the nucleus to the oocyte cytoplasm (Fig. 4). With still longer incubation period of 4 h the intensity of labelling increases in the trophocyte cytoplasm (Fig. 5). In 6 h one finds a gradient of labelling in the germarium, the proximal part is less radioactive than distal part, showing the movement of radioactive molecules from the cephalic pole to the posterior region (Fig. 3). But this does not produce strong accumulation of the label in the trophic cords, suggesting that very long incubations are needed for the trophic cord labelling.

The behaviour of germinal vesicle with tritiated uridine has been studied in the oocytes. With short as well as long incubation periods the germinal vesicle becomes labelled and it is interesting to note that germinal vesicle of stage I and stage II are more radioactive as compared to stage III, where it is practically unlabelled. With 2 h incubation the germinal vesicle becomes heavily labelled in stage I and stage II oocytes and it is interesting to note that the oocyte nuclei of the transition zone are more radioactive as compared to that of stage I and stage II (Fig. 4). With 6 h incubation period (Figs. 6,7), the labelled molecules from the germinal vesicle move into the oocyte cytoplasm, but this does not produce a very strong accumulation of the label in the perinuclear zone, suggesting that the movement is either passive or slow. So a limited autosynthesis of RNA in germinal vesicle, in young oocytes upto stage II is indicated, but not beyond this stage.

DISCUSSION

The trophocytes are the main centers for RNA supply in both polytrophic and telotrophic types of ovaries. The synthesis mainly occurs in their large polyploidal nuclei, which is transported to the oocyte through the intercellular bridges (fusomes) in the polytrophic ovarioles (RAMAMURTY, 1963 ; BIER, 1963a, b, 1967 ; ENGELS, 1970 ; KING, 1970) or through the trophic cords (nurse strand) in the telotrophic ovarioles (MAYS, 1972; BUNING, 1973; MACGREGOR & STEBBINGS, 1970 ; ULLMANN, 1973). However, most of them have identified the product as ribonucleoprotein (RNP) (BIER, 1965 ; MELIUS, 1966). Labelling of the trophic cords in Coleoptera with ^{3}H-uridine requires very long incubation periods of nearly 48 h or more (BIER, 1967 ; ULLMANN, 1973) as compared to 2½ h to 6 h in polytrophic ovariole (RAMAMURTY, 1963 ; BIER, 1967). These reports show that the rates of RNA synthesis and its export to the oocytes varies in different insect species. In *Menochilus*, however, the passage of labelled molecules could not be detected in trophic cords with longest incubation period of 6 h employed in the present study.

RNA synthesis by the oocyte nucleus could be demonstrated here at least upto stage II though VANDERBERG (1963) and MACGREGOR & STEBBINGS (1970) could not find any evidence of RNA synthesis in the oocyte nucleus of telotrophic ovarioles.

In panoistic ovaries, the germinal vesicle was shown to be continuously active in synthesising RNA (ZALOKAR, 1960 ; FAVARD-SERENO & DURAND, 1963; HIGHNAM,

1967), but in the meroistic ovaries the oocyte nucleus remains inactive and does not participate in RNA synthesis. Certain exceptions from this rule, however, are reported for various insect groups, as in adephagous beetle (URBANI & RUSSO-CALA, 1964, 1969 ; BIER & RIBBERT, 1966 ; BIER *et al.*, 1967 ; FICQ & URBANI, 1969), the black fly *Simulium* (ZALOKAR, 1965) and lacewing *Chrysopa* (GRUZOVA *et al.*, 1972). BIER *et al.* have pointed out that the limited amount of label associated with the karyosome of housefly, need not necessarily indicate chromosomal synthesis. They have been derived from the nurse cell RNA which attaches itself to the chromosomes and inhibits the latter from synthesis. In the present study on *Menochilus*, a clear migration of label out of germinal vesicle could be demonstrated with the incubation period of 6 h, at least upto stage II. Thus the present case of *Menochilus* seems to represent an intermediate condition between the polytrophic ovarioles where the germinal vesicle is practically idle throughout, and the panoistic ovarioles where it is active in RNA synthesis throughout. Thus there are two different sources of RNA supply to the oocytes during previtellogenic stages where mainly euplasmic growth takes place.

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LEGEND TO FIGURES

Fig. 1. (top left) Autoradiogram of germarium with 15 min incubation with ^{3}H-uridine showing the restricted labelling of trophocyte nuclei. × 480.

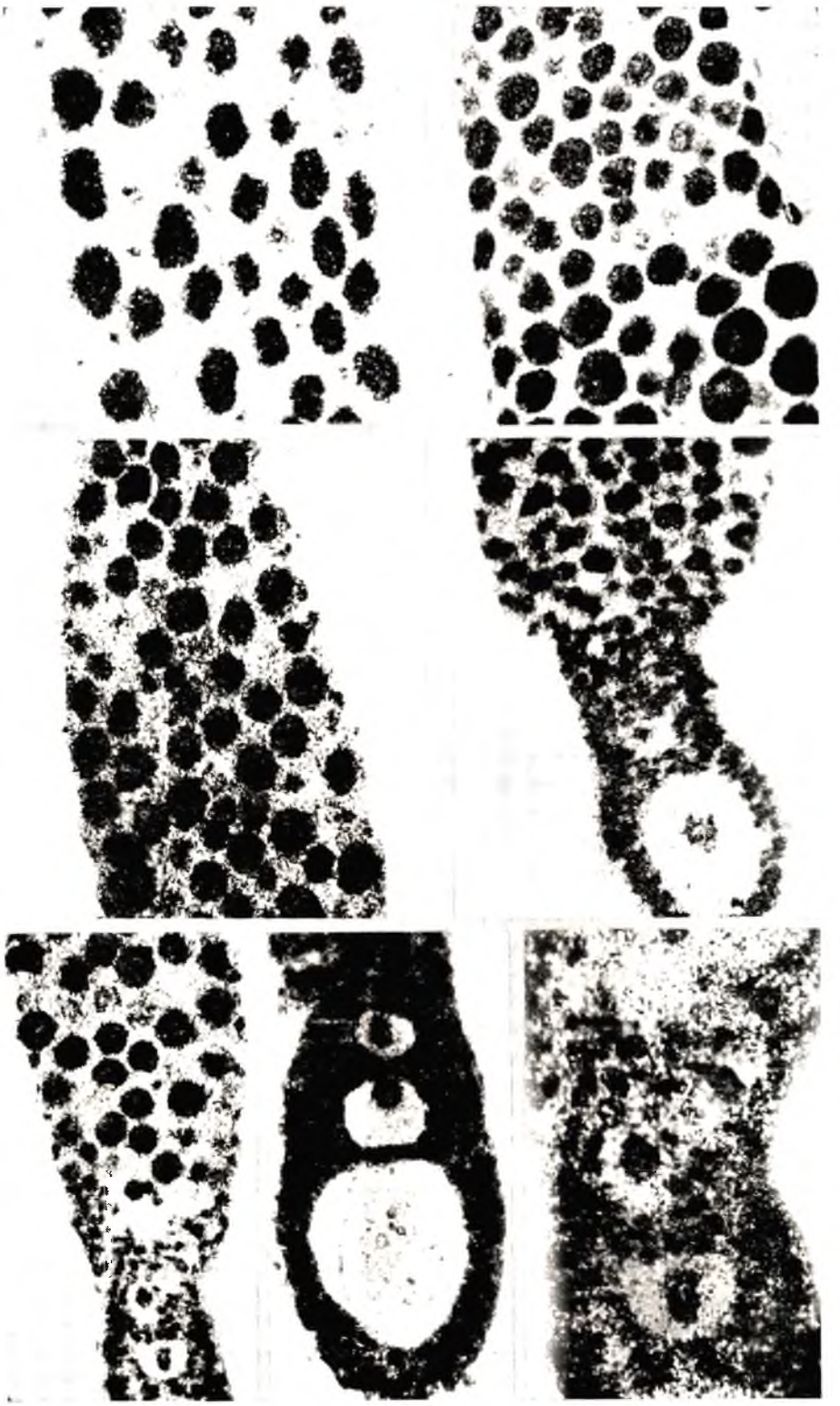
Fig. 2. (top right) Same as above with 1 h incubation. Note the increase in the radioactivity of the trophocyte nuclei. × 480.

Fig. 3. (middle left) Autoradiogram of germarium showing the incorporation pattern after 6 h incubation with ^{3}H-uridine. Note the heavy labelling of trophocyte nuclei and the radioactivity in the cytoplasm. The posterior part of germarium is more radioactive than cephalic pole. × 480.

Fig. 4. (middle right) An autoradiogram of an ovariole showing incorporation pattern in the germarium above, and vitellarium below, with follicle stage I and stage II, after 2 h incubation. The trophocyte nuclei are heavily labelled with a transient labelling of cytoplasm. Note the radioactivity of the germinal vesicle in stage I and stage II oocytes and in the early oocytes in transition zone. × 375.

Fig. 5. (lower left) Shows the incorporation pattern of ^{3}H-uridine in the germarium above and vitellarium below, with 4 h incubation. Specific strong labelling of trophocyte nuclei and moderate labelling of the trophocyte cytoplasm is evidenced. × 375.

Figs. 6 (lower middle) and 7 (lower right) Autoradiographs of stage I and II oocytes showing the incorpoaration pattern of the germinal vesicle. Note also the movement of radioactivity from the germinal vesicle into the ooplasma. Incubated with ^{3}H-uridine for 6 h. × 375 and × 480 respectively.



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EFFECT OF X-RAYS ON CIRCADIAN RHYTHMICITY OF GLYCOGEN CONTENT IN THE COCKROACH, *PERIPLANETA AMERICANA* L.

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X-irradiation at sublethal and lethal doses caused an elevatory effect on glycogen content in the central nervous system (CNS) and coxal muscles (CM) of the cockroach. Non-irradiated control group exhibited clear rhythmic pattern in glycogen content with a peak period registered at 08.00 hrs alternating with a nadir at 00.00 hrs midnight. Sublethal dose exposure caused phase shifts of 4 hrs delay (60°) in peak periods, while lethal dose irradiation could induce faster rhythm with an additional peak period in CM and only a phase shift in CNS. These results suggest the persistency of circadian rhythm in glycogen content in spite of metabolic derangement due to X-irradiation.

(Key words : **X-irradiation, cockroach,** *Periplaneta americana*, **central nervous system, coxal muscles, rhythmic pattern, glycogen)**

INTRODUCTION

A survey of literature has shown the existence of different types of rhythms (behavioural and physiological) in the cockroach (BRADY, 1967a, b, 1969 ; HARKER, 1974; VIJAYALAKSHMI, 1977). The circadian pattern of enzymes and metabolites has been reported to be influenced by varied doses of X-irradiation (VIJAYALAKSHMI, 1977; VIJAYALAKSHMI *et al.*, 1977b). Rhythmic fluctuations in running activity of cockroach (HARKER 1958) and orientation of snails and planarians (BROWN *et al.*, 1970) in response to ionizing radiation have been demonstrated. But no attempt was made previously to analyse the rhythmicity of glycogen, the labile reserve of energy metabolism in the cockroach. In view of this, the present study depicts the presence of cyclic variation in glycogen in the coxal muscle and nervous tissue of the cockroach, *Periplaneta americana* L. An attempt was also made to investigate further the effects of sublethal and lethal doses of X-irradiation on this cyclic activity in the cockroach, as it was already stated that ionizing radiation could bring in significant alteration in energy metabolism of *Periplaneta* (VIJAYALAKSHMI *et al.*, 1977a).

MATERIALS AND METHODS

Adult male cockroaches of 1.0 to 1.25 gm weight-range were selected for experimentation. The mode of exposure and the parameters employed were described earlier (VIJAYALAKSHMI *et al.*, 1977a). After single whole-body irradiation, the animals were maintained in a temperature and humidity controlled room (27±2°C, 75±5% RH) provided with a 12 : 12 light-dark cycle. A nonirradiated control group was included along with irradiated colony. Both control and experimental animals were fed *ad libitum* and were starved for 24 hr prior to the experimentation in order to prevent the entry of dietary carbohydrates.

Two days after exposure central nervous system (CNS) and coxal muscle (CM) of irradiated and control animals were isolated in ice-cold condition (below 5°C) during different periods viz., 08.00 12.00, 16.00, 20.00, 00.00 and 04.00 hr to cover 24

hr of diel cycle. Tissue homogenates prepared in ice-cold trichloro-acetic acid (10% W/V) solution were employed for the estimation of glycogen content.

Glycogen was assayed by using anthrone reagent method of SCIFTER *et.al.*, (1950) and expressed as mg of glycogen per gm wet weight of tissue.

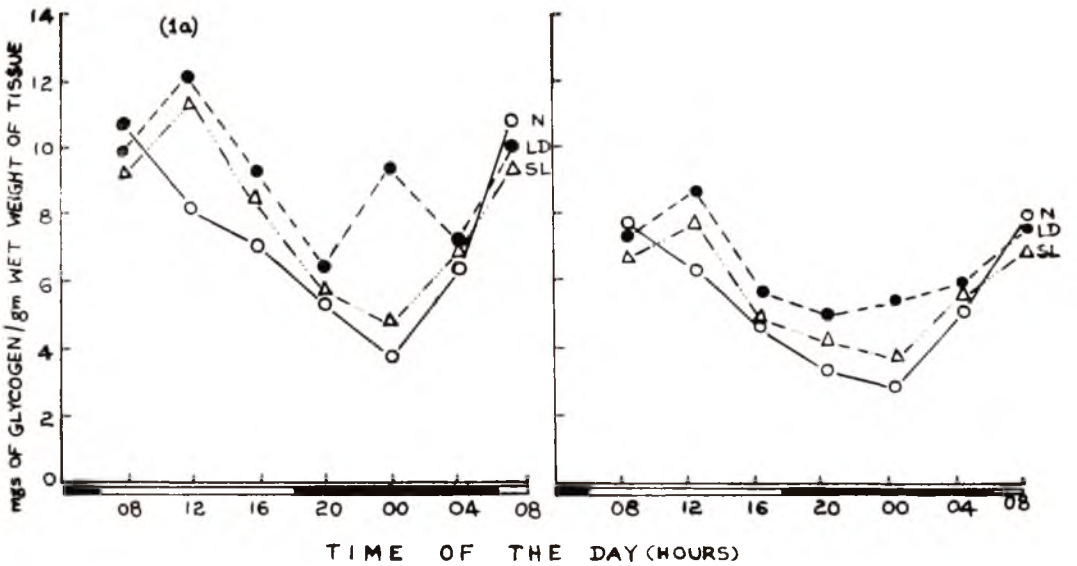
1/3 of LD_{50} (3,500 R) was designated as sublethal (SL) and LD_{50} (10,500 R) as lethal dose (LD) and determination of LD_{50} was carried out as per the method of DRASTADT (1975).

RESULTS AND DISCUSSION

Table 1 depicts higher level of glycogen in the coxal muscle when compared to CNS. This suggests that CM has more functional significance in that, the muscle glycogen is one of the prime carbohydrate reserves for the animal. Moreover, the precursors of muscle glycogen include the glucose and trehalose from the haemolymph and lactic acid produced from glycogen itself during muscle contraction.

From Fig. 1 a and 1 b it is clear that *Periplaneta* exhibited a distinct cyclical variation in glycogen content in CNS and CM under normal day-night cycle (LD/12: 12) with a peak period confining to the early hours of dawn (08.00hrs). The maximal period was alternated with a nadir at 00.00 hrs midnight. Statistical treatment of the data revealed significant ($P < 0.002$) rise and fall in glycogen level from minimal and *vice versa* in both the tissues showing the presence of a typical rhythmicity in glycogen content of the control cockroaches.

The occurrence of peak period for glycogen, which is a major source of energy metabolism, at 08.00 hrs (i.e., during light hours of the day) is in contrast to the nocturnal behaviour of the animals. Similar circadian fluctuations in glycogen were reported in the tissues of rats (MAYERSBACH, 1970), scorpions (CHENGALRAJU *et al.*, 1973) and in slugs (PAVAN KUMAR, 1976). The higher level of glycogen during light hours (08.00 to 16.00)



Effect of X-irradiation on circadian rhythmicity of glycogen content in the central nervous system (Fig. 1 a left) and coxal muscle (Fig. 1 b right) of *Periplaneta americana*. N : Normal; SL : Sublethal dose; LD : Lethal dose

TABLE 1. Circadian rhythmicity in glycogen content of *Periplaneta*. (The content is expressed as mg of glycogen/gm wet wt of tissue).

	Peak	Nadir	MGL	PDN	A	B
Normal :						
CNS	08.00	00.00	6.85 ±0.43	—	8.62 ± 0.46	5.08 ±0.39
CM	08.00	00.00	5.07 ±0.38	—	6.31 ± 0.31	3.81 ±0.44
Sublethal dose:						
CNS	12.00	00.00	7.89 ±0.40	+14.84	9.64 ± 0.45	6.14 ±0.34
CM	12.00	00.00	5.56 ±0.37	+ 9.67	+ 6.56 ± 0.33	4.59 ±0.38
Lethal dose:						
CNS	12.00		8.53 ±0.42	+24.52	10.45 ± 0.38	6.94 ±0.46
CM	12.00	20.00	6.42 ±0.29	+26.63	7.32 ± 0.31	5.53 ±0.26

± : Standard deviation of 5 observations.
MGL : Mean glycogen level.
PDN : Per cent deviation over normal.
A : Average glycogen levlel during light hours (08.00 to 16.00) of the day.
B : Average glycogen level during dark hours (20.00 to 04.00) of the day.
CNS : Central nervous system.
CM : Coxal muscle.
\+ : increment.
Each value was the mean of five individual observations. For each observation a total number of 15 animals were used.

than during dark hours (20.00 to 04.00) may be attributed to the existence of varied time periods in the replenishment and depletion of glycogen in the tissues of *Periplaneta*. Hence, it is probable that more amount of glycogen might be metabolised through aerobic and anaerobic pathways to meet the energetic and synthetic demands of the animal during its active phase of the day. The net result would be the less amount of glycogen with a nadir at 00.00 hrs midnight which is in synchrony with a reversal trend in peak activity period at 00.00 hrs (180° out of phase) for phosphorylase (the key enzyme playing vital role in the breakdown of glycogen in *Periplaneta* (VIJAYALAKSHMI *et al.* 1977 b).

The diel variations observed in the present study are thus linked with nocturnal monophasic locomotor activity (GUNN, 1940 ; HARKER 1974) and energy metabolism (VIJAYALAKSHMI, 1977) of the animal. In support of this investigation VIJAYALAKSHMI (1977), and RAJARAMI REDDY *et al.*, (1977) have demonstrated higher succinic dehydrogenase and adenosine triphosphatase activities respectively in the cockroach during dark hours of the day. Interestingly lactic dehydrogenase the glycolytic enzyme, showed a peak activity period during inactive hours of the day (12.00 noon) but an advancement by 4 hrs (VIJAYALAKSHMI, 1977). Thus these synchronous and varied peak acti-

vity periods bring out the fact, the existence of multiple rhythms within the same organism under normal diel cycle (LD/12: 12). The same interrelationship between the phases of several rhythmic processes within one organism may become dissociated as a consequence of differential rates of phase-shifting. These multiple rhythms in various biological constituents have their role to play and are significant as adaptive mechanism, depending on the physiological state of the animal. The sum total of all these activities are reflected as the overt behaviour of the animal.

The data presented in Table 1 represent significant elevation in glycogen level under sublethal and lethal doses of X-irradiation in the tissues of *Periplaneta*. This rise in glycogen level may account for (a) enhanced rate of glycogenesis or glyconeogenesis (b) inhibition of glycolysis and (c) accelerated protein catabolism. From the figures it is evident that there is persistency of rhythmic pattern in glycogen level after X-ray exposure in spite of dose dependent derangement in glycogen metabolism. Under sublethal dose exposure the animals exhibited delayed peak by 4 hrs (12.0 noon in both CNS and CM while LD exposure resulted in the occurrence of an additional peak period at 20.00 hrs in the CM (Fig. 1 b). The original trend in glycogen level during LD cycle was maintained (Fig. 1 b), thus suggesting the persistency of the diel rhythm of the metabolite, glycogen, by extrinsic factors like light and radiation. Phase shifts were also documented by HARKER (1958) in free running activity of *Periplaneta* under different doses of X-irradiation. Similarly BROWN *et al.* (1970) and WEVER (1973) demonstrated the occurrence of phase shifts due to electromagnetic fields and gamma radiation in planarians, snails and human beings. However, HARKER (1964) suggested that phase shifts occurring within 4 hrs are within the limitations of the period range viz., 24 hrs on enzyme-metabolite system. It has also been documented in cockroaches (VIJAYALAKSHMI *et al.*, 1976) and slugs (PAVAN KUMAR, 1976) that environmental light conditions also act as Zeitgeber in bringing about phase shifts in peak periods of activity in response to changing photoperiods.

Induction of phase shifts and faster rhythm with two or more peak periods under sublethal and lethal doses of X-irradiation may be due to metabolic derangement at subcellular level. The additional peak period in CNS suggests significant disturbances in glycolytic and glycogenetic pathways. The altered condition imposed on the animal demands high quanta of energy, which might be availed through enhanced facultative metabolic modifications at cellular and subcellular level. Enforcement of phase shifts and faster rhythm may be followed by physiological stress and pathological disorder. As suggested by WAGNER *et al.*, (1974) the faster rhythm occurring within 24 hr period reflects high frequency-oscillations. This high frequency oscillatory rhytm in turn may depend on the availability of key metabolites or enzymes which regulates metabolic pathways. Similarly in vertebrates development of double peak periods representing faster rhythm (GEARLUCE, 1971) are apparently in corroboration with the present observations.

Thus, the biological alterations at macromolecular level (enzymes or metabolites) were considered to be one of the sources for the overt behaviour of the animal (NISHIITSUTSUJI *et al.*, 1967). Though the animal is sensitive to X-irradiation, the original rhythic pattern was persistent and in turn provides a potential source of

information to the organism for adjustment to the environmental changes. Moreover, majority of investigators agree that the persistence of rhythm under varied imposed conditions reflect the probable endogenous nature of the biological clock regulating the rhythmic behaviour of the animal.

Acknowledgement:- The financial assistance rendered by UGC (to SV) and CSIR (to GRR & TPK) is gratefully acknowledged.

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BIOLOGY AND HABITS OF THE RICE CASE WORM *NYMPHULA DEPUNCTALIS* GUEN. IN KERALA

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In Kerala the life cycle of *Nymphula depunctalis* GUENEE (Pyraustidae, Lepidoptera) the rice case worm is completed in 33 to 43 days during June-July. Larval and adult habits are described. *Bracheria ramosa*, *B. mutica*, *Panicum repens*, *Cynodon dactylon*, *Cyperus rotendus* and *C. iria* are alternate hosts. Amount of leaf tissues eaten by the larva varies on different rice varieties and it is negatively correlated with the larval and pupal durations. Moth population shows 2 peaks in November-December and May-June and these peaks coincide with high rainfall periods.

(*Key words:* *Nymphula depunctalis*, **rice case worm, biology**)

INTRODUCTION

The case worm Nymphula depunctalis GUENEE (Pyraustidae : Lepidoptera) is ranked among the major pests of rice in Kerala and in the other States of Tamil Nadu, Kranataka, Andhra Pradesh, Orissa, Bihar, Assam and Manipur (GHOSH *et al.* 1956). AYYAR (1938) recorded briefly the life history and nature of damage of the insect. SISON (1938) studied its biology and habits in the Philippines. VIRAKTAMATH (1974) worked out in detail the biology of *N. depunctalis* at Bangalore. Additional information on the pest with reference to the biology, seasonal occurrence and host plant relations of the insect gathered in studies undertaken in Kerala (at the College of Agriculture, Vellayani) are presented in this paper.

MATERIAL AND METHODS

Observations on the biology of *N. depunctalis* were made by rearing it on 35 days-old rice plants raised in pots. The potted plants were enclosed in glass cylinders, 4.5 × 22.5 cm, open at both ends. The top openings were closed with muslin colth. To study the feeding of the larva on different rice varieties, 5 first instar larvae were released on 35 days-old rice varieties enclosed in glass cylinders and the area of leaf eaten measured on graph paper on alternate days with three replications for each variety. The survival of the caterpillars on alternate hosts was determined by releasing first instar larva on the different hosts planted in pots and enclosed in the glass cylinders. Only those host plants on which the larva could complete its development were considered as alternate hosts of the insect. All these studies were made in the insectary where the temperature varied from 20° C to 31°C and relative himidity from 77.0% to 88.0%.

To study the seasonal fluctuation of the population of *N. depunctalis* in the field the moths collected from the rice fields in sweeps with sweep net 25.0 cm square were counted at fortnightly intervals. There were three replications of 10 sweeps each and the moth-counts were made all the year round.

RESULTS

Observation on the biology and habits of N. depunctalis:

The eggs hatch in 5 to 6 days and there are 6 larval instars. The measurements and duration of the larval instars are given in Table 1. Pupal duration lasts from 5 to 6 days. The total life-cycle is completed in 33 to 43 days during the months of June-July on the rice variety *Jaya*. In general the size of the caterpillar in the present studies has been seen to be much less than that reported by VIRAKTAMATH *et al.* (1974).

TABLE 1. Size and durations of larval instars of *N. depunctalis* (mean of 10 observations).

Larval instar	Length (mm)	Width of head (mm)	Length of larval case (mm)	Duration (days)
First	1.2	0.30	8.0	4.0
Second	2.1	0.43	11.5	4.5
Third	3.3	0.58	14.0	4.5
Fourth	4.9	0.78	16.5	3.5
Fifth	8.0	0.96	19.0	3.5
Sixth	12.0	1.30	22.5	2.5

Larval habits

The first instar larva on hatching moves about on the leaf and gets itself attached to a water drop or a dew drop on the leaf surface. Then it starts scraping the leaf surface feeding on the green tissues. It then moves to the tip of the leaf and cutting a slit on the margin at a point 2–3 cm below the leaf tip, makes a leaf fold at the tip and occupies it feeding on the surface tissues. Later during the instar the larva makes a second cut about 1 cm below the first, rolls the margin and fastens it with silk to form a tubular case, occupies it and moves about with it. During the first and second instars more than one larva may be seen to inhabit one case while a single larva inhabits a case in the later instars. A new case is made by the larva after every moult. For making the case each time the larva cuts down the leaf tip together with the case and after feeding on the severed leaf, cuts itself free from it. The larva with the case falling on the surface paddles itself with the aid of the extended body to reach plants. The larva in all its instars feeds by scraping the green matter of the leaves in linear patterns leaving epidermis and veins in tact. Feeding is retarded under dry conditions and presence of water particles on the leaves is always favourbale for the free feeding.

Adult habits

The moths mate and oviposit during night. Durng day time they rest among rice leaves in the field. Most of the eggs are laid in the night following mating and the moth dies thereafter during the same night. Eggs are laid on both surfaces of the leaf to a height of 30 cm on standing crop, mostly in single rows and rarely in spread out groups. The number of eggs laid per female varies from 145 to 165 and the average number of eggs in a group is 49.1. The male moths live for 4 to 5 days and unmated females for 5 to 6 days.

Alternate hosts

Bracheria ramosa, *Panicum repens*, *Cynodon dactylon*, *Cyperus iria*, *Cyperus rotendus*, *Monocoria vaginalis*, *Echinocloa colonum* and *Fimbristilis miliaceae* tested for suitability as alternate hosts of *N. depunctalis*, 6 species viz. *B. mutica*, *B. ramosa*, *B. repens*, *C. dactylon*, *C. rotendus* and *C. iria* were found to serve as alternate hosts, the larva being able to complete its development on these weeds.

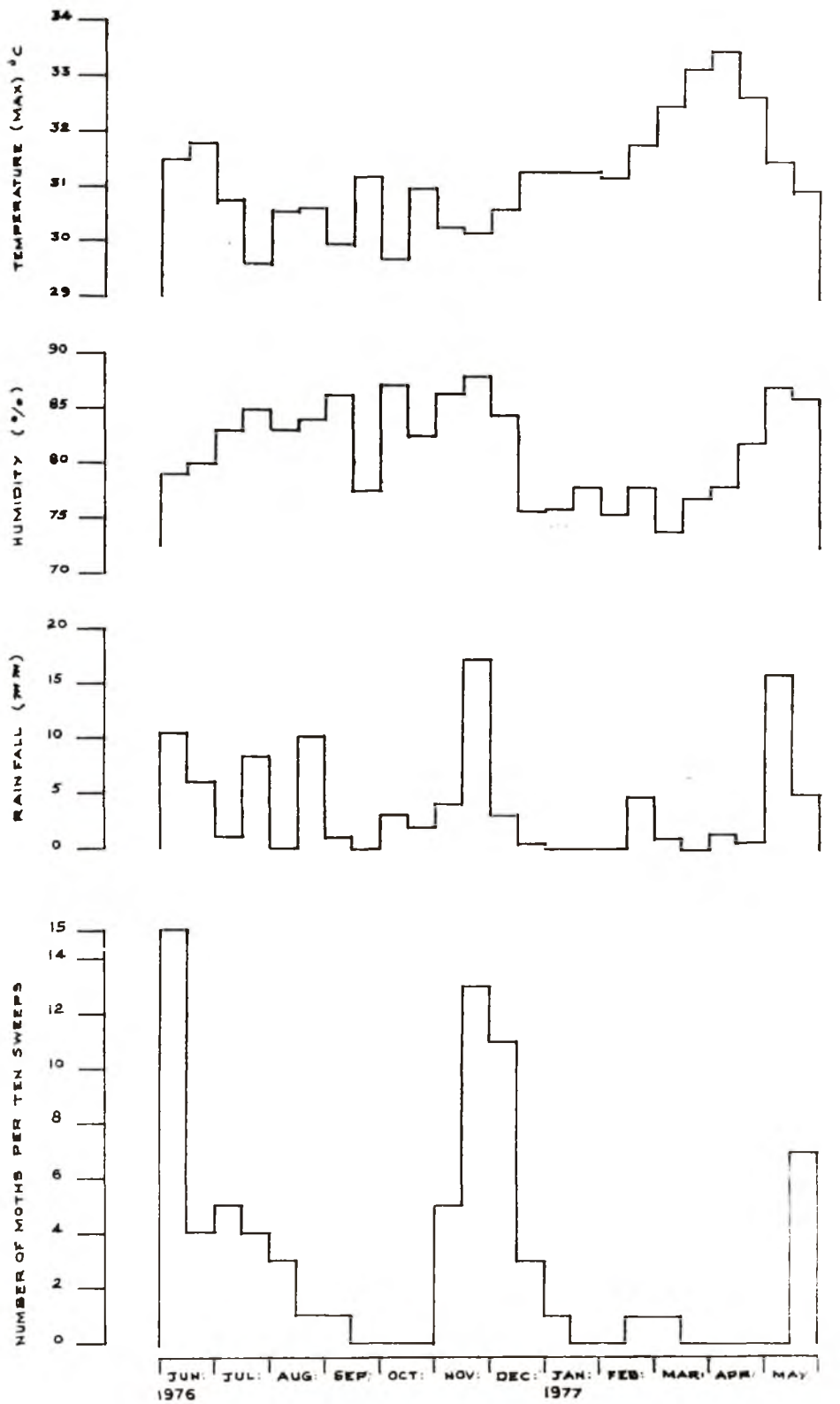

Fig. 1. Fluctuation of population of moths *N. depunctalis* in relation to climatic features.

TABLE 2. Feeding and development of *N. depunctalis* on defferent rice varieties (Mean of 5 observations).

Rice variety	Leaf area eaten per larva in 11 days (sq cm)	Larval duration (days)	Pupal duration (days)	Larval and pupal duration combined (days)	Growth index
Aswathi	21.8	23.5	10.0	33.5	2.98
Cauveri	25.2	19.0	6.8	25.8	3.87
Sabari	26.2	23.5	9.7	33.2	2.97
Bharathi	26.7	23.0	7.5	30.5	3.28
IR-20	26.7	18.5	5.8	24.3	4.11
Padma	27.9	20.5	7.8	28.3	3.54
Annapurna	28.3	22.0	8.5	20.5	3.28
Jaya	29.4	19.5	6.3	25.8	3.87
Thriveni	47.6	16.8	4.8	21.6	4.63

Correlation coefficients (re)
Larval feeding vs. combined larval and pupal durations — 0.6766*
Larval feedings vs. growth index 0.7464
*Significant at 0.05 level.

Response to rice varieties

Feeding of the larva and the larval and pupal durations vary on different rice varieties (Table 2). In general the quantity of leaf eaten on the one hand and the combined larval and pupal durations on the other are negatively correlated, the coefficient of correlation being 0.6766 which is significant. The growth index is positively correlated with the feeding of the caterpiller, the coefficient of correlation being 0.7464 and significant. The life-cycle of the insect is thus completed at a faster rate on rice varieties like *Thriveni*, IR-20, *Jaya* and *Cauveri* which are favoured by the caterpillar for feeding than on varieties such as *Aswathi* and *Sabari* which are less favoured for feeding.

Seasonal fluctuation of population

Population of the moth of *N. depunctalis* is seen to reach peaks during November–December and May–June (Fig. 1). These peaks coincide with high rainfall and high humidity periods. Variation in temperature does not appear to be correlated with moth population.

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JOGOCERUS GEN. NOV. AND NEW SPECIES OF IDIOCERINE LEAFHOPPERS FROM SOUTHERN INDIA (HOMOPTERA : CICADELLIDAE)

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Descriptions and illustrations of the new idiocerine genus *Jogocerus*, its type species, *J. freytagi* sp. nov. and five new species of *Idioscopus* namely, *pretiosus*, *bellus*, *spectabilis*, *dworakowskae* (from Karnataka) and *virescens* (from Kerala) are given. Their relation with other idiocerine leafhoppers is discussed.

(*Key words* : **new idiocerine genus *Jogocerus***)

Idiocerine leafhoppers of the Indian subcontinent have been recently treated by Maldonado Capriles (1961, 1964, 1965), Anufriev (1970) Ghauri (1975) and Viraktamath (1976). It appears that the idocerine fauna of India is far more diversified and rich than it is presently understood. In this paper a new genus and six new species discovered during recent field trips in the states of Karnataka and Kerala (South India) are reported.

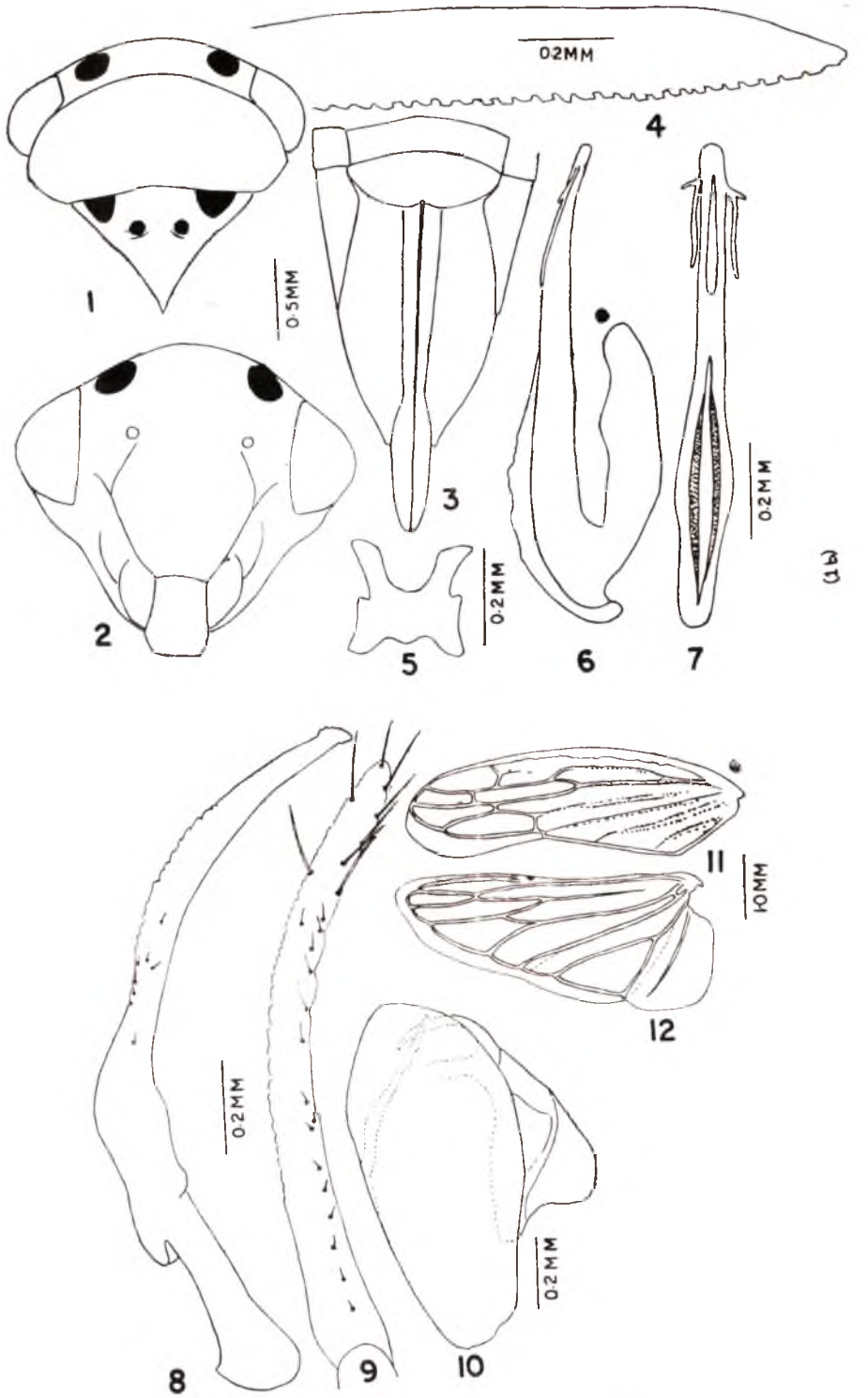
The holotypes of the species described here will be deposited in the Zoological Survey of India, Calcutta, and the paratypes in the British Museum (Natural History), London, U. S. National Museum, Washington, D. C. and in the University of Agricultural Sciences, Bangalore.

Jogocerus gen. nov.

Head distinctly wider than pronotum. Eyes projecting. Vertex and face dorsad of ocelli finely transversely rugose. Face including eyes wider than long. Clypellus projecting beyond genae, gradually widened distally and truncate. Pronotum finely transversely rugose, four times longer than median length of vertex and about half as long as broad. Scutellum slightly longer than pronotum, its surface reticulate except two basal triangles and two central round spots which are shagreened, disc with two oblique impressed lines. Basal half of forewing veins and claval veins lined on either side with series of circular pits, four apical and one complete and one incomplete anteapical cells. Spinulation of hindfemur 2+1.

Female ovipositor strongly projecting beyond pygofer. Second pair of valvulae with a series of almost square tipped teeth; first pair of valvulae sharply pointed apically and with a series of obliquely parallel grooves on their dorsal apical half.

Male pygofer with well developed dorsal apodemes, anal collar process and ventral pygoferal process. Male plate elongate narrow with a few hair-like setae. Style with apophysis ventrally feebly serrate. Connective deeply excavated distally. Aedeagus with a well developed dorsal apodeme forming an 'U' with the shaft. Aedeagal shaft with lateral and caudal



Figs. 1–12. *Jogocerus freytagi* gen. et sp. nov. 1. Head and thorax; 2. Face; 3. Female genitalia; 4. Second valvula; 5. Connective dorsal view; 6. Aedeagus, lateral view; 7. Aedeagus, caudal view; 8. Male style, lateral view; 9. Male plate; 10. Male pygofer; 11 & 12. Fore and hind wings.

ridges at base, and terminated by a pair of processes. Gonopore preapical.

Type-species : *Jogocerus freytagi* gen. et sp. nov.

Remarks:

Jogocerus resembles *Tasnimocerus* Ghauri in the shape of pronotum which is transversely rugose, but differs from it in having a narrow based clypellus and by its distinct male genitalia. It shares the character of ventral pygoferal process with *Amritodus* Anufriev, but the transversely rugulose pronotum, U-shaped aedeagus, distally excavate connective distinguishes it.

1. Jogocerus freytagi sp. nov. (Figs. 1–12)

Greenish-yellow in life; preserved specimens yellowish-brown to yellowish-green. Two somewhat round spots on vertex, two triangles at basal angles of scutellum black. Two smaller round spots on scutellum, two larger spots on mesosternum and claws dark fuscous. Forewings smoky. Abdomen greenish-yellow. Ocelli pinkish. Eyes either grey or black.

Vertex either of uniform length or slightly longer in the middle than next to eyes. Clypellus gradually widened distally. Lora semicirular, slightly raised from genae. Ocelli closer to adjacent eyes than to each other. Labium extending just beyond mesocoxae. Vertex 6.3 times as wide between eyes as its median length. Pronotum almost half as long as its breadth, posterior margin slightly concave. Scutellum slightly longer than pronotum, with two median oblique impressed lines. Hindfemoral spinulation 2 + 1 but in one male the left femur with 2+2 while the right one with 2 + 1.

Female genitalia:

Hindmargin of seventh sternite convexly produced and projecting beyond the pygofers. The second pair of valvula as in Fig. 4.

Male genitalia

The pygofer with well developed dorsal apodemes and anal collar process which is slender and curved ventrally. Pygofer with a broad unpigmented central area and more or less rhomboidal, its ventral process straight and directed caudodorsally. Male plates of uniform width with an uneven inner margin. Style elongate almost as long as male plate, apophysis broad in the middle, caudo-dorsally curved and with serrated ventral margin and apex (Fig.8). Connective as in Fig. 5. Dorsal apodeme of aedeagus well developed, shaft dorsally directed with a pair of slender subapical processes, each with a lateral short tooth; basal half of the shaft with a pair of lateral smooth ridges and a caudal sharp edged, uneven margined ridge. Gonopore subapical, elongate and caudal.

Measurements:

Males 5.07 (5.0–5.21) mm in length, 1.77 (1.75–1.8) mm in width. Females 6.0 (5.8–6.07) mm in length, 1.97 (1.93–2.0) mm in width.

Holotype ♂ INDIA: KARNATAKA, Jog Falls, 17.xi.1976, C. A. Viraktamath Coll. 1♂ 6♀♀ **paratypes** with same locality data as holotype but 1♀ collected by B. Mallik; 2♂♂ and 4♀♀ = collected by the author on 18.xi.1976.

The species is named in honour of Dr. Paul H. Freytag, Department of Entomology, University of Kentucky, Lexington, U. S. A.

Genus **Idioscopus** Baker

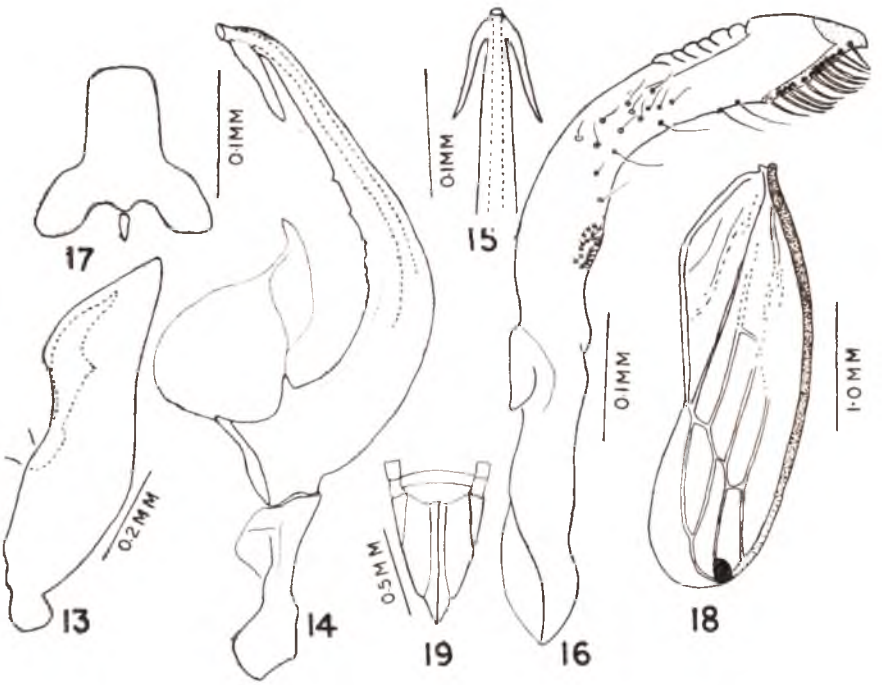
The genus *Idioscopus* Baker (Type-species, *Idiocerus clypealis* Lethierry) was redefined by Maldonado Capriles (1964), who transferred several species of *Idiocerus* Lewis

described from the Oriental Region to this genus (Maldonado Capriles, 1964, 1965 and 1973). Freytag and Knight (1966) described seven species from Madagascar and differentiated the *Idioscopus* from *Idiocerus* by the presence of a subapical spine on the hindfemur in addition to the two apical ones. It is observed that in a few species of *Idioscopus* the aedeagus is devoid of any processes, a character much stressed by Maldonado Capriles (1964) in his diagnosis of the genus.

2. Idioscopus pretiosus sp. nov. (Figs. 13–19)

Vertex and pronotum lemon-yellow. Face whitish-yellow. Eyes black except on inner margin. Basal segments of antennae whitish yellow, flagellum of female uniformly smoky, in male yellowish-white with a black band in the middle where it is lightly thickened. Lateral margins of pronotum pale brown. Scutellum yellowish-white with two basal pale brown short triangles. Forewing, except broad costal transparent area, smoky-brown, third apical cell with a dark brown to black spot. Legs greenish-ochraceous, bases of hindtibial spines, apices of hindtarsi and pretarsi reddish-brown. Abdominal sterna and lateral margins of terga yellowish-green, rest of terga black. Ovipositor apically black.

Head wider than pronotum. Vertex medially longer than next to eye, 2.9 to 3.0 times wider than its median length, rugose dorsad of ocelli. Labium reaching the apices of mesothoracic coxae. Pronotum shagreened, 1.4 times longer than median length of vertex, 2.75 times wider than long. Scutellum longer than pronotum, shagreened, with two oblique median impressed lines. Forewing venation as in Fig. 18.



Figs. 13–19. *Idioscopus pretiosus* sp. nov; 13. Male pygofer; 14. Connective and aedeagus, lateral view; 15. Tip of the aedeagal shaft; 16. Male style, lateral view; 17. Connective, dorsal view; 18. Forewing of female; 19. Female genitalia.

Male genitalia: Dorso-caudal margin of pygofer angulately curved, the ninth tergal apodemes well developed, anal collar process simple, caudally attenuated. Male plates elongate and margined by long hair-like setae. Style dorsally curved near the middle, ventral margin subapically crenulate, apex sclerotized, dorsally margined by setae. Connective Y-shaped. Aedeagus with weakly sclerotized dorsal apodeme, shaft curved, anterior margin obscurely serrated, with a pair of subapical ventrally directed processes, near apex curved anteriorly; gonopore apical and anterior.

Female genitalia: The seventh sternite slightly produced posteriorly and medially slightly excavated. The ovipositor slightly extended beyond pygofers.

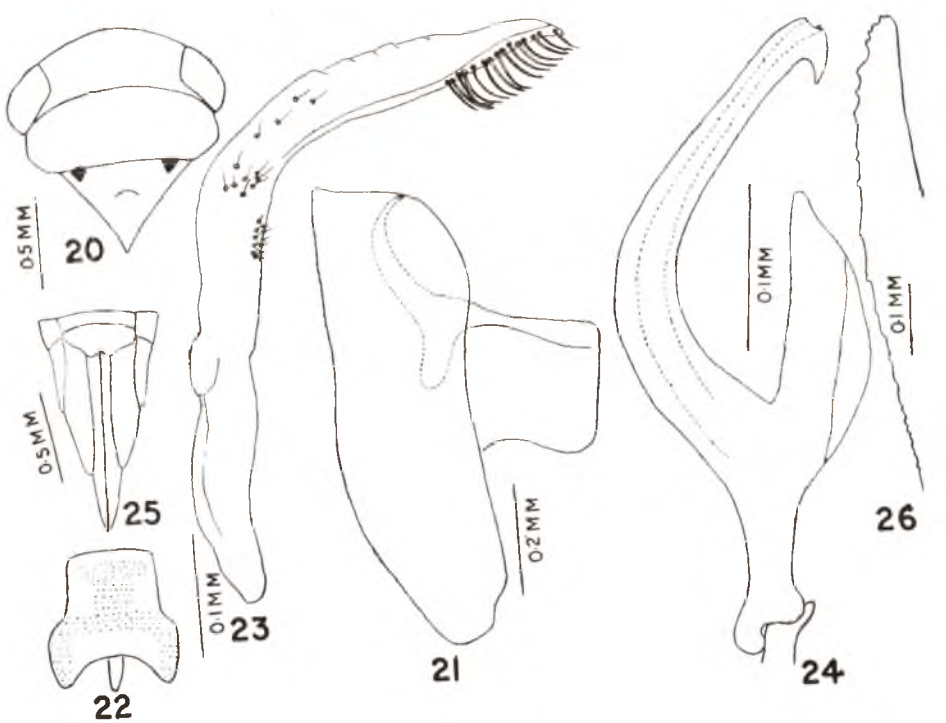
Measurements: Male and female 3.57 mm in length and 1.23 mm in width.

Holotypes ♂ INDIA : KARNATAKA, Mudigere, 22.v.1976, C. A. Viraktamath. 3 **paratype** ♀♀ with same data except one collected by B. Mallik.

Remarks: This species is distantly related to *I. decoratus* Viraktamath from which it differs in colouration and in having distinct male genitalia. It very much resembles *I. bellus* sp. nov. from which it can be differentiated by its paired aedeagal process.

3. **Idioscopus bellus** sp. nov. (Figs. 20–26)

Colouration similar to *I. pretiosus* with the following differences. Apex of clavus



Figs. 20–26. *Idioscopus bellus* sp. nov; 20. Head and thorax; 21. Male pygofer; 22. Connective, dorsal view; 23. Male style, lateral view; 24. Aedeagus, lateral view; 25. Female genitalia; 26. Second valvula.

with greenish–yellow patch on smoky–brown ground colour; Scutellum lemon-yellow with two pale brown triangles at base. Lateral brownish colouration of the pronotum not prominent.

Head wider than pronotum. Vertex slightly longer medially than next to eyes, three times as wide between eyes as its median length, transversely rugose. Face wider than long, dorsad of ocelli rugulose. Pronotum 1.6 times longer than the median length of vertex, 2.7 times as wide as its median length, shagreened. Scutellum 1.4 times longer than pronotum.

Male genitalia: Pygofer elongate apically broadened with bluntly pointed caudal end. Anal collar process slender directed caudo–dorsally then mesally and pointed apically. Style much narrower at apex than in *I. pretiosus*, ventral margin with faint broad crenulae. Aedeagus with well developed dorsal apodeme and preatrium; shaft recurved about the middle then almost straight with an apical short blade–like ventrally directed process on its anterior margin; gonopore terminal, both anterior and caudal margins smooth. Connective broadly T–shaped.

Female genitalia: Seventh sternum posteriorly produced and notched medially. Ovipositor projecting well beyond pygofers; much longer than in *I. pretiosus:* second pair of valvulae as in Fig. 26.

Measurements: Male 3.57 (3.3–3.64) mm in length and 1.2 (1.2–1.22) mm in width; females 3.64 (3.57–3.71) mm in length and 1.22 (1.2–1.25) mm in width.

Holotypes ♂ INDIA : KARNATAKA, Jog Falls, 19.xi.1976, C. A. Viraktamath Coll. 6 ♂♂ and ♀ ♀ **paratypes** with same label data as the holotype but 2 ♀ ♀ collected on 17.xi.1976, and 1 ♀ collected by B. Mallik.

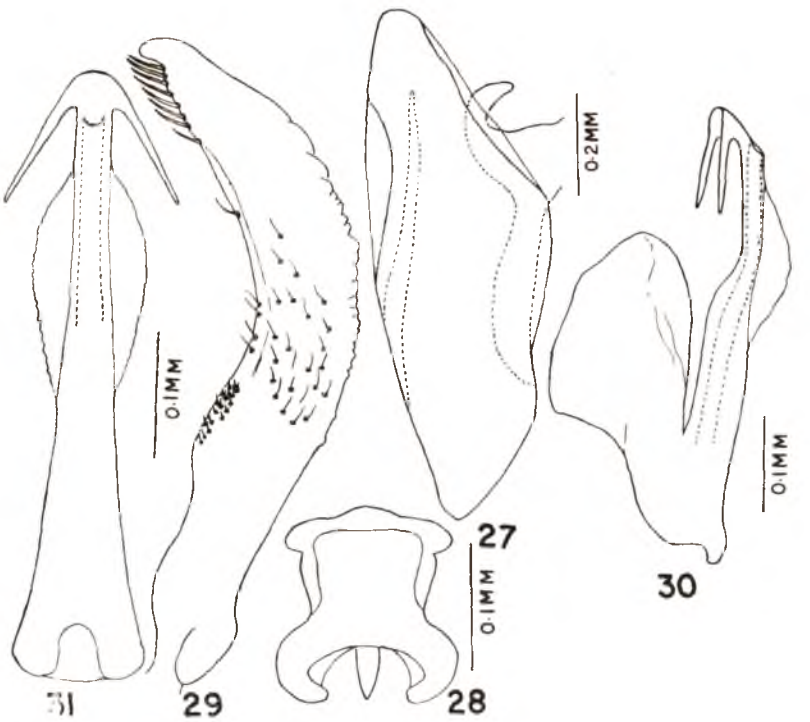
Remarks: I. bellus externally resembles *I. pretiosus* to which it is closely related. The lemon-yellow scutellum, unpaired anterior process of the aedeagal shaft, apically narrowed style, slender anal collar and the female seventh sternite distinguish this species.

4. Idioscopus virescens sp. nov. (Figs. 27–31)

Head, pronotum, scutellum and most of clavus bright yellowish–green. Outer margins of clavus bluish–white, rest of forewing brownish. Sternites and legs ochraceous. Apical spinulation of hindtibiae and tarsi reddish–brown. Antennae of the male with a black flagellar band.

Vertex distinctly longer medially than next to eyes, 2.5 times as wide between eyes as its median length, transversely rugose. Face broader than long, ventrad of ocelli shagreened, dorsad of ocelli transversely rugose. Labium short hardly exceeding the procoxae. Ocelli inconspicuous. Flagellum of male antennae with a lightly thickened area in the middle. Pronotum 1.7 times as long as the median length of vertex, 2.5 times as wide as long and shagreened. Scutellum longer than pronotum, shagreened basally and rugose distally. Forewing with three apical and one anteapical cells.

Male genitalia: Pygofer with well developed anterior tergital apodemes; with an elongate ventral pygoferal process and with a distinct unpigmented area in the middle, along dorsal and dorso–caudal margins. Anal collar simple with a short finger–like process. Connective as in Fig. 28. Style laterally curved, ventrally crenulate with setae on disk and on apical dorsal margin of apophysis. Aedeagus with a strongly developed dorsal apodeme, basal half of shaft almost straight then slightly curved where it is laterally expanded into two caudo–laterally directed lamellate processes with finely serrated margin; apex



Figs. 27–31. *Idioscopus virescens* sp. nov; 27. Male pygofer; 28. Connective, dorsal view; 29. Male style, lateral view; 30. Aedeagus, lateral view; 31. Aedeagus, caudal view.

of the shaft terminated by an anterior pair of ventrally directed short processes; gonopore subapical and caudal.

Unique male measured 4 mm in length and 1.4 mm in width.

Holotypes ♂ INDIA: KERALA, Maraiyur, 24.ii.1977. Shashidhar Viraktamath Coll.

Remarks: I. virescens is unique among the members of the genus in having the shaft laminately expanded at its distal half. It shares characters of the ventral pygoferal process with *I. decoratus*. This species, judging from its structure and male genitalia appears closer to *I. pretiosus* and *I. bellus*.

5. Idioscopus spectabilis sp. nov. (Figs. 32–38)

Head, pronotum and scutellum lemon–yellow. Lateral spot on eye, two round spots on upper part of face (absent in male), a discal spot on pronotum, basal half of scutellum and a spot on each forefemora of male (absent in female), black. In male, a fuscous spot on either side of discal spot of pronotum and the black area of scutellum medially interrupted by fuscous area. Legs ochraceous with piceous pretarsus. Forewings except broad costal area smoky–brown, apex of clavus along inner margin greenish–yellow. Abdominal sterna and lateral area of terga greenish–yellow. Ovipositor fuscous basally and black apically.

Head wider than pronotum. Vertex medially longer than next to eye, 3.3 to 3.6 times wider than its median length. Vertex and face dorsad of ocelli transversely rugose. Face wider than long, clypellus not extending beyond the normal curve of gena. Labium

slender exceeding the apices of metathoracic coxae. Male antennae without terminal disc. Pronotum shagreened, 2.0 to 2.3 times loger than median length of vertex and 2.4 to 2.5 times wider than its median length. Scutellum medially longer than pronotum, basal half shagreened, apical half beyond median impressed line finely transversely rugulose. Forewing venation as in Fig. 37.

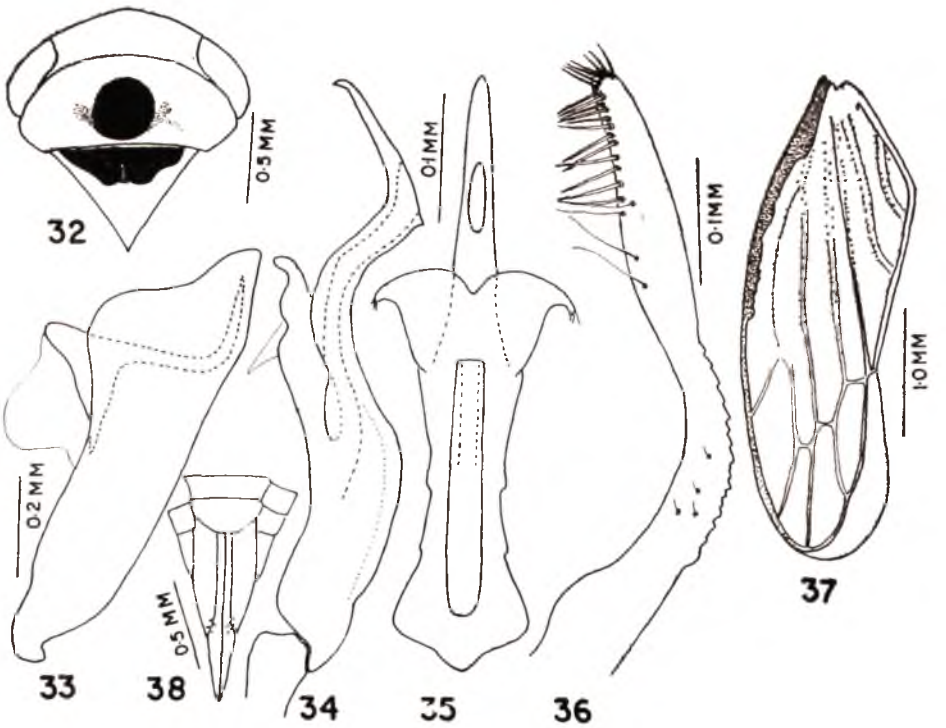
Male genitalia: Pygofer narrow and elongate, dorsocaudally somewhat angulate and with well developed ninth tergal apodemes on anterior margin. Anal collar process simple, elongate, near midlength directed dorsad at almost right angles. Male plate long, narrow and fringed with long, hair–like setae. Style curved, ventral margin serrate and dorsally margined with setae near apex. Aedeagus sinuate with an elongate atrium, dorsal apodeme short, shaft beyond gonopore attenuated. Gonopore subapical and caudal.

Female genitalia: Hindmargin of the seventh sternite caudally produced and medially convex. Ovipositor extending well beyond pygofers.

Measurements: Male 4.0 mm in length and 1.4 mm in width. Female 4.0 and 4.3 mm length and 1.45 and 1.5 mm in width.

Holotype ♂ INDIA: KARNATAKA, Jog Falls, 8.v. 1976, B. Mallik 2 ♀♀ with same data as the holotype.

Remarks: I. spectabilis and *I. dworakowskae* sp. nov. juding from the male genitalia are very close to each other though externally tney are very different. *Specta-*



Figs. 32–38. *Idioscopus spectabilis* sp. nov; 32. Head and thorax; 33. Male pygofer; 34. Aedeagus, lateral view; 35. Aedeagus, cephalic view; 36. Male style, lateral view; 37. Forewing of female; 38. Female genitalia.

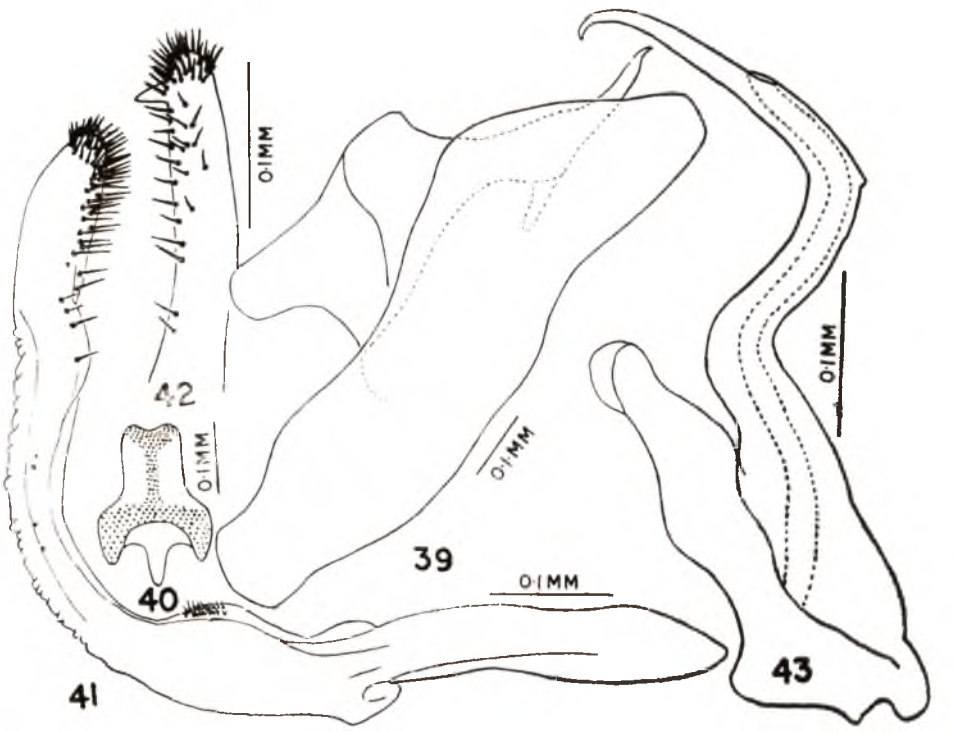
bilis can be distinguished by its discal black spot on the pronotum.

6. Idioscopus dworakowskae sp. nov. (Figs. 39–43)

Pale brown. Two round spots on upper part of face visible from dorsal aspect on anterior margin of vertex black. Antennal pit medially dark fuscous. Eyes dark grey with a lateral black spot. Two triangular spots at base of scutellum black, area between them and anterior to median impressed line brown; rest of scutellum yellow. Forewings with brown veins lined with dark brown pits. Mesal margin of foretibiae apically black, the setae arising from this area blackish; bases of setae and apices of hindtibiae reddish brown; claws black.

Vertex of uniform length, about 4 times as wide between eyes as its median length, transversely rugose. Face wider than long, shagreened. Labium long reaching posterior extremities of hindcoxae. Pronotum 2.5 times longer than median length of vertex and 2.7 times as wide as long, shagreened. Scutellum longer than pronotum, with a median impressed line, area anterior to it granulose, posterior to it finely rugulose. Forewing with four apical and two anteapical cells, all veins with a double row of pits except distally.

Male genitalia: Pygofer elongate with strongly developed anterior apodemes, caudally rounded with a large subapical pigmented area. Anal collar well developed with a caudally directed, attenuated process. Style



Figs. 39–43. *Idioscopus dworakowskae* sp. nov; 39. Male pygofer; 40. Connective, dorsal view; 41. Male style, lateral view; 42. Apex of male style; 43. Aedeagus, lateral view.

elongate, laterally strongly curved, ventrally crenulate, dorsally covered with setae in rows but apically clothed with setae and with mesal tooth. Connective T-shaped with a median prolongation on its proximal margin. Aedeagus with well developed dorsal apodeme, atrium elongate, large, shaft strongly curved first caudally and then antero-dorsally ; shaft beyond gonopore slender attenuated and at its tip ventrally directed.

Male measured 4.15 mm in length and 1.6 mm in width.

Holotype ♂ INDIA : KARNATAKA, Jog Falls, 19.xi.1976, C. A. Viraktamath and 1 ♂ **paratype** (teneral) with same locality data but collected on 17.xi. 1976.

Remarks: Externally resembles *Idioscopus clypealis* (Lethierry), and could be distinguished from it by its distinct male genitalia, and by the absence of black spots on vertex. The species is named in honour of Dr. Irena Dworakowska, Warszawa, Poland.

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ORIENTAL SPECIES OF *CREMNOPS* FOERSTER (HYMENOPTERA : BRACONIDAE)

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Sixteen species of *Cremnops* now known from the Oriental Region are treated here. Five new species *viz.*, *sculpturalis*, *philippinensis*, *kapili*, *malayensis* and *indica* are described from India, Philippines, Java, Sulawesi and Halmahera. Redescriptions of *C. lemniscatus* and *C. posticeniger* Enderlein are given from their types. A key to the Oriental species is provided here for their identification.

(*Key words :* **Oriental *Cremnops*, new species**)

The genus *Cremnops* Foerster belongs to the sub-family Agathidinae of the family Braconidae. It is a large genus and cosmopolitan in distribution. In the Oriental Region it has been reported from almost all parts. In India these insects are reported at the elevation of 1219.20–2133.60 metres. A revision of the Oriental species of *Cremnops* has not been attempted so far. But Cameron (1899, 1907), Ashmead (1904), Szepligeti (1905, 1908) and others have described a number of species from the Oriental Region. Baltazar (1963) has transferred a number of species to other genera. According to Shenefelt (1907) thirteen species are reported from the Oriental Region. *Cremnops desertor* Linn. is not included in the key because of its inadequate description. *Cremnops persimilis* Enderlein from Java is synonymized with *Cremnops fuscipennis* (Brulle) because the descriptions of both species are same. Types of *C. posticeniger* and *C. lemniscatus* Enderlein were available for the present study and for other known species their published descriptions proved adequate to compare them with species and include them in the key.

Genus **Cremnops** Foerster

Cremnops Foerster, 1862, *Verh. Naturhist. ver. Rheinlande*, **19** : 246: Type: *Ichneumon desertor* Linnaeus (= *Agthis deflagator* Nees); monobasic and original designation. *Bracon* Viereck, 1914, *Bull. U.S.Natl. Mus.*, **83**:23.

Taxonomy : Ashmead, 1904 : 23. Baltazar, 1962 : 762; 1963 : 3. Marsh, 1961 : 852. Muesebeck, 1927 : 7. Shenefelt, 1970: 382. Szepligeti, 1905 : 25; 1908 : 29.

Face rostriform, narrowed towards the labrum; malar space 3–5 × the basal width of mandible and 0.5–0.8 × the eye height; mandible bidentate; mouthparts usually elongated type; facial tubercles between antennae distinct; frons bordered by marginal and lateral carinae; occipital carinae absent; eyes moderately large and not emarginate; notauli distinct, smooth or transversely carinated; mesopleural furrow usually absent or represented by smooth very small depression near the midcoxa; prepectal carina reaching mid height of mesopleurum; submetapleural ridge distinct and pointed; propodeum areolated; spiracle oval to elongate; abdomen moderately long, smooth or sculptured; fore and middle claws cleft with pectination; ovipositor long.

1. Type-spcies: *Ichneumon desertor* Linnaeus

This genus is often confused with *Isopironotum* Enderlein due to the presence

of rostrum and pectinate claws but the latter genus can be separated by the absence of notauli and well developed mesopleural furrow.

A KEY TO THE ORIENTAL SPECIES OF *CREMNOPS* FOERSTER

1. First abdominal tergite reticulate; body entirely golden yellow; apex of hindtibia and tarsus black. Nepal.....1. *sculpturalis* sp. nov.

— First abdominal tergite shiny and smooth; body colour varies from yellow to black; hindleg usually black.....2

2. Vertex to whole of head black.....3

— Head entirely yellow or yellowish-red.....10

3. Scutellar depression with three longitudinal carinae. Kalimantan.....2. *satapensis* Cameron

— Scutellar depression with one longitudinal carina.....4

4. Basal 0.66 of wings clear hyaline to yellowish-hyaline with apex light brown; ocellar triangle not raised [except in *modestus* (Smith)].....5

—Wings dark brown to black with a few hyaline spots; ocellar triangle raised [not known in *persimilis*) and fuscipennis (Brulle)].....8

5. Basal 0.66 of wings yellowish-hyaline and apical 0.33 dark brown with a brown stigmal spot at the base of stigma reaching the hinder end of forewing; stigma yellow; either ocellar area or entire head black and rest of body yellow to reddish-yellow; propodeal carinae strong.....6

— Basal 0.66 of wings clear hyaline and apical 0.33 brown with a brown stigmal spot at the base of stigma reaching hinder end of forewing; stigma black; head reddish-yellow (except in *philippinensis*, sp. nov.); abdomen and hindleg black; propodeal carinae weak.....7

6. Malar space longer than the eye height; ocellar area black; base of stigma yellow and apex brown. Kalimantan.....3. *borneanus* Cameron

— Malar space less than the eye height; head entirely black; stigma entirely yellow. Java, Sulawesi and Halmahera.....4. *modestus* (Smith).

7. Body stout and entirely black with white pubescence; nervulus mesad of basal vein; scutellum without lateral carinae; stapes long. Philippines.....5. *philippinensis*, sp. nov.

— Thorax, foreleg, middle tibia and tarsus reddish-yellow; body slender without any remarkable pubescence; nervulus distad of basal vein; stipes very short; scutellum with thin lateral carinae. India.....6. *indica*, sp. nov.

8. Basal 0.33 of wings yellow and apical 0.66 dark brown. Java.....7. *fuscipennis* (Brulle)

— Basal 0.33 of wings either clear hyaline or dark brown.....9

9. Wings entirely brown with one hyaline spot; body with white pubescence; second intercubitus emiting a short vein. Sulawesi and philippines.....8. *nitidus* (Smith)

— Wings brown with more than two hyaline spots; second intercubitus not emitting any short vein; thorax with pubescence.....9. *collaris* Ashmead.

10. Ocellar triangle raised; wings dark brown; abdomen black; propodeal tubercles weak.....11

— Ocellar triangle not raised; wings basally hyaline; abdomen yellow (except in *posticeniger* Enderlein); propodeal tubercles distinct and pointed.....12

11. Abdomen wide and stout; body with yellow pubescence; nervulus strongly distad of basal vein. Philippines.....10. *kapili*, sp. nov.

— Abdomen long and narrow ; nervulus weakly distad of basal vein. Singapore and Philippines.....11. *bispinosa* Szepligeti.

12. Stigma entirely brown; nervulus strongly distad of basal vein; forewing with one hyaline spot at the base of stigma or without any hyaline spot.....13

— Basal 0.5 of stigma yellow and apical 0.5 brown; nervulus weakly distad of basal vein; forewing with two hyaline spots, one at the base of stigma and other at the apex of forewing.....14

13. Interocellar distance 0.6×the ocello-ocular distance and 2×the distance between median and lateral ocelli; forewing with one hyaline spot at the base of stigma; thorax and abdomen yellowish-red; apex of hindtibia and tarsus brown. Taiwan, Palaeractic and Nearctic.....12. *atricornis* (Smith)

— Interocellar distance 0.33× the ocello-ocular distance and 1.0× the distance between median and lateral ocelli; forewing without any hyaline spot; meso- and metapleurae, propodeum, abdomen and hindleg dark brown. Sumatra.....13. *posticeniger* Enderlein.

14. Mesoscutum distinctly and sparsely to closely punctate, its middle lobe with a carina; wings light brown with three hyaline spots 15

— Mesoscutum shiny and smooth, its middle lobe without any carina; basal 0.5 of wings yellowish and apical 0.5 brown with a brown stigmal spot. India, Nepal and Sumatra.....14. *lemniscatus* Enderlein.

15. Mesopleural furrow absent; wings hyaline near base, its apex light brown; mesoscutum sparsely punctate. Malaya.....15. *malayensis*, sp. nov.

— Mesopleural furrow present with eight stout transverse carinae; wings yellowish-hyaline at base and apex light brown; mesoscutum and scutellum closely punctate. India.....16. *nigritarsis* (Cameron)

1. **Cremnops sculpturalis** sp. nov.

This species is characterized by having reticulate first tergite and golden yellow body with yellow pubescence. The two intercubiti in the forewing are parallel.

Male : Face and clypeus shiny, sparsely punctate, 1.2× as long as wide; stipes moderately long; malar space 5× the basal width of mandible and 1.0× the eye height; frontal and marginal carinae distinctly raised; vertex shiny with a few punctures; ocellar triangle not raised, interocellar distance 0.5× the ocello-ocular distance and 2× the distance between median and lateral ocelli; mesoscutum shiny with a few punctures its middle lobe with a median longitudinal carina, notauli distinct and smooth; prescutellar depression with one longitudinal carina; scutellum shiny and smooth, without any lateral or apical carina; mesopleurum shiny, very sparsely punctate; mesopleural furrow absent; metapleurum sparsely punctate with a pointed submetapleural ridge; propodeum moderately carinated, basal and apical areas with a few transverse carinae, its apicolateral tubercles not pointed; second cubital cell squarish; first and second intercubiti parallel, without emitting any short vein, nervulus distad of the basal vein; hindfemur 3 × as long as wide, hindtibial spur 0.4× as long as hindbasitarsus; abdomen shiny, first tergite reticulate, 1.7× as long as its apical width, 2–3 tergites 0.8× as long as wide with a faint groove at basal 0.5 of the second tergite.

Golden yellow. Antenna, apex of hindtibia and tarsus dark brown; wings brown 0.5 of stigma yellow and apical 0.5 brown with a hyaline spot at base of stigma reaching hinder end of forewing.

Female : Unknown.

Length : ♂, 8mm; forewing 7mm.

Holotype : ♂, NEPAL: HIMALAYA: Godavari, 1500m, 29. iv. 1970, T. Chand No. 348 (Gupta).

Distribution : Nepal.

This species approaches *lemniscatus* Enderlein in punctation and colour pattern of body and wings but presence of reticulate first tergite justifies the identity of *sculpturalis*.

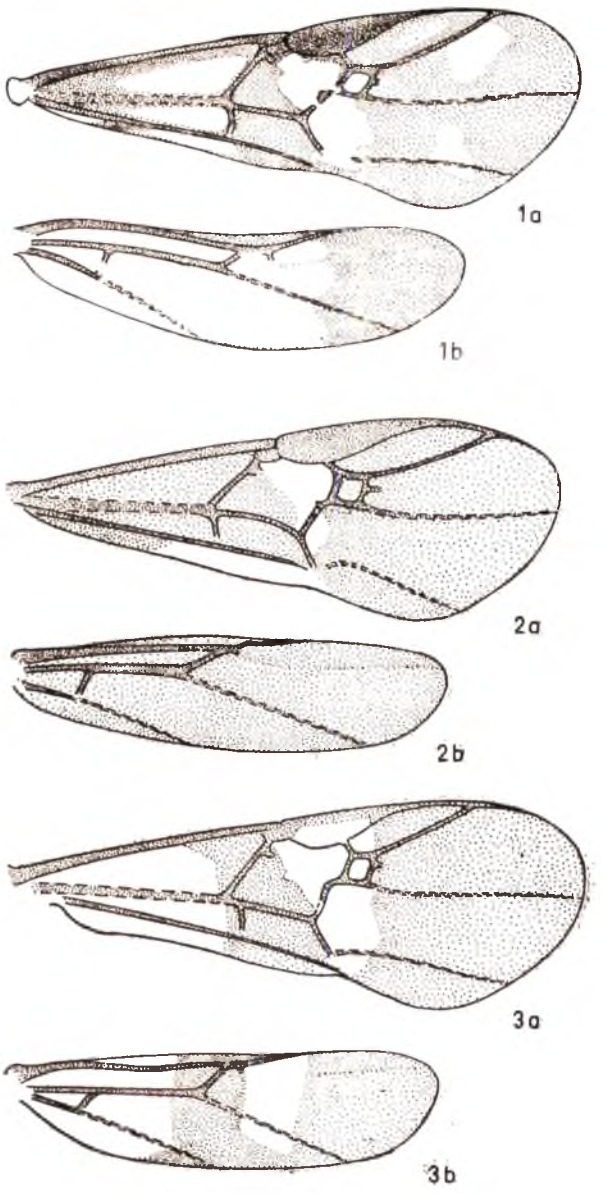
2. **Cremnops satapensis** Cameron

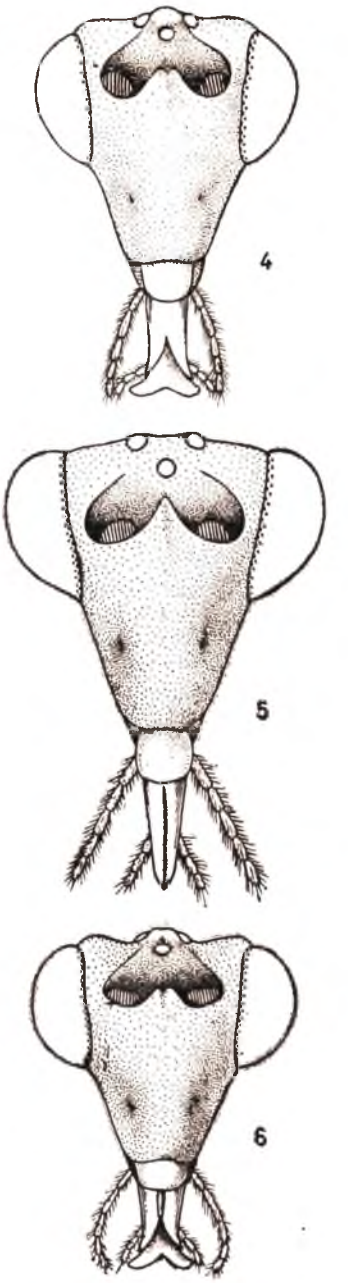
Cremnops satapensis Cameron 1907., *Entomologist*, **14**: 230. Type ♂, Kalimantan: Stap (London).

This species is known from its type locality only. It can be separated by the characters given in the key.

3. **Cremnops borneanus** Cameron

Cremnops borneanus Cameron, 1906, *J.*





Figs. 1–3. Colour pattern of fore- and hindwings of : 1 a–1b. *Cremnops collaris* Ashmead; 2a–2b. *C. nitidus* (Smith); 3a–3b. *C. modestus* (Smith). Figs. 4–6. Front view of head of: 4. *C. collaris* Ashmead; 5. *C. modestus* (Smith); 6. *C. indica*, sp. nov.

Straits Brch. R. Asiat. Soc., **46** : 113. Type ♂, Sarawak : Kuching (London).

This species is very close to *modestus* (Smith) but can be separated by the characters given in the key.

4. Cremnops modestus (Smith) Figs. 3a, 3b & 5)

Agathis modesta Smith, 1858, *J. Linn. Soc.* (*Zool.*), **3** : 25. Type ♀, Sulawesi : Makassar (Oxford).

Cremnops modesta : Baltazar, 1963, *Acta Hymenopt. Tokyo*, **2** (1) : 2.

This species can be recognized by the following characters : Abdomen long; basal 0.66 of wings yellowish-hyaline and apical 0.33 brown with a brown spot at the base of stigma reaching hinder end of the forewing; head black and rest of the body yellowish-red; propodeal carinae and its apicolateral tubercles distinct; first and second intercubiti not parallel; face distinctly punctate.

Female : Face sparsely and distinctly punctate; face and clypeus 1.3 × as long as wide; malar space 4 × the basal width of mandible and 0.8 × the eye height; stipes long (Fig. 5); facial tubercles distinct; vertex shiny and sparsely punctate; ocellar triangle not raised (Fig. 5), interocellar distance 0.5 × the ocello-ocular distance and 2 × the distance between median and lateral ocelli; mesoscutum shiny sparsely punctate, slightly raised, its middle lobe with a median longitudinal carina, notauli distinct and smooth; prescutellar depression with one longitudinal carina; scutellum shiny and smooth with an apical carina; meso- and metapleurae shiny, very sparsely punctate, mesopleural furrow absent; submetapleural ridge distinct; propodeal carinae strong, basal and apical areas with a few transverse carinae, apicolateral tubercles pointed; first and second intercubiti not parallel, second intercubitus emitting a short vein; hindfemur 3.5 × as long as wide; abdomen shiny and smooth, long and stout, first tergite 1.7 × as long as its apical width, 2+3 tergites 1.7 × long as the apical width, second tergite without any transverse groove.

Yellowish-red. Head, antennae, apex of hindtibia and tarsus dark brown; basal 0.66 of wings yellowish-hyaline and apical 0.33 brown with a brown stigmal spot reaching hinder end of forewing (Fig. 3a), stigma entirely yellow, basal veins yellow and apical veins brown.

Male : Unknown.

Length : ♀, 10–11 mm, forewing 9–10mm.

Specimens examined : 3 ♀ ♀. JAVA : Puntjak, 1828.80 m, 1 ♀, x. 1965, J.E. Lukavsky (OTTAWA). SULAWESI, 1 ♀, 3.iii. 1965, J. E. Lukavsky (OTTAWA). HALMAHERA Is., ca 500m, 1 ♀, 1965, A.M.R. Wegener (OTTAWA).

Distribution : Java, Sulawesi and Halmahera.

This species is unique among the species of *Cremnops* in having yellowish-hyaline wings and elongated face.

5. Cremnops philippinensis sp. nov.

This species is close to C. *satapensis* Cameron in having black body, basal third of wings hyaline and fore and middle legs yellowish but the former species can be separated by having only one longitudinal carina in the prescutellar depression.

Female : Face distinctly elongated and punctate; face and clypeus 1.3 × as long as its maximum width; stipes long, malar space 4 × the basal width of mandible and 0.6 × the eye height; ocellar triangle not raised, interocellar distance 0.44 × the ocello-ocular distance and 2 × the distance betwen median and lateral ocelli; vertex shiny and very

sparsely punctate; mesoscutum sparsely punctate, its middle lobe depressed with a median longitudinal carina, notauli distinct, weakly and transversely carinated; prescutellar depression with one longitudinal carina; scutellum convex, sparsely punctate without any carina; meso- and metapleurae sparsely and distinctly punctate; mesopleural furrow absent; submetapleural ridge weakly protruding; propodeal carinae weak, areas on propodeum rugose, its apicolateral tubercles weakly formed; first and second intercubiti parallel without emitting any short vein, nervulus either misad or a little distad of the basal vein; hindfemur 4.5 × as long as wide, hindtibial spur 0.5 × as long as hindbasitarsus; abdomen shiny and smooth, first tergite 2.2 × as long as its apical width; 2+3 tergites 1.4 × as long as wide, second tergite with a faint transverse impression at its basal 0.33.

Black. Face reddish-brown; mouthparts, fore and middle coxae, trochanters and femora brown; fore and middle tibiae and tarsi yellowish; apical 0.25 of wings light brown and basal 0.75 hyaline, stigma and veins brown.

Male : Unknown.

Length : ♀, 9.5mm; forewing 7mm.

Holotype ♀, PHILIPPINES : MINDORO : S. Luis, Calapan, 45.72m, 10. iv. 1954, H.M. & D. Townes. **Paratypes** 4 ♀ ♀. MINDORO : Alcate Vict., 2 ♀ ♀, 5. iv. 1954, H. M. & D. Townes; 1 ♀, same data as holotype; MINDORO : Ilong, Mt. Halcon, 914.40m, 1 ♀, 10.v. 1954, M.T. & D. Townes (ALL TOWNES).

Distribution : Philippines.

6. Cremnops indica *sp. nov.* (Fig. 6)

This species can be recognized by the following characters: Thorax, foreleg, middle tibia and tarsus reddish-yellow; body short and slender without any remarkable pubescence; stipes short; nervulus distad of the basal vein; scutellum bordered by thin carinae.

Female : Face shiny, sparsely and distinctly punctate; face and clypeus 1.5 × as long as its maximum width; stipes very short (Fig. 6); malar space 3.2 × the basal width of mandible and 0.8 × the eye height; vertex with a few minute punctures; ocellar triangle raised (Fig. 6), interocellar distance 0.66 × the ocello-ocular distance and 2 × the distance between median and lateral ocelli; mesoscutum shiny with a few scattered punctures, its middle lobe raised with a longitudinal carina, notauli narrow and smooth; prescutellar depression with one longitudinal carina; scutellum with very few punctures, with thin lateral and apical carinae; mesopleurum shiny and smooth, mesopleural furrow absent; dorsal 0.5 of metapleurum sparsely punctate and ventral 0.5 rugosely punctate; submetapleural ridge moderately prominent; propodeum with white pubescence, basal and apical areas confluent with a transverse carina, its apicolateral tubercles weak; first and second intercubiti parallel without emitting any short vein, nervulus distad of basal vein; hindfemur 3.6 × as long as wide, longer hind tibial spur 0.5 × as long as hindbasitarsus; abdomen shiny and smooth, first tergite 1.5 × as long as its apical width, 2+3 tergites 1.1 × as long as wide, second tergite with a faint transverse impression at its basal 0.5.

Dark brown. Mouth parts, pronotum, mesoscutum, scutellum and mesopleurum reddish yellow; variation in the colour of fore and middle legs from yellow to brown; apical 0.45 of wings light brown and basal 0.55 clear hyaline with a brown stigmal spot reaching hinder end of forewing, stigma and veins brown.

Male : Unknown.

Length : ♀, 6.6mm, forewing 6 mm.

Holotype ♀, INDIA : TAMIL NADU, Devala, Nilgiri Hills, 975.36m, x. 1962, P.S. Nathan (OTTAWA). **Paratypes** 61 ♀ ♀. 3 ♀ ♀, same data as the holotype (OTTAWA); KARNATAKA : Tithimatti, S. Coorg, 6 ♀ ♀, 16–30. xii. 1941 (R. R. D. 111, Ex. No. 2153) ex *Hapalia machaeralis* (defoliating teak)., R. N. Mathur (F.R.I.); 1 ♀, same data as above, 8.ii.1942 (defoliating *Tenctona grandis*) (F. R. I.); TAMIL NADU : Top Slip, 45 ♀ ♀, ex *Hapalia machaeralis*, 25 ♀ ♀, 10–30.viii–ix, 1959, (R.R.D. 2442, 2443), 6 ♀ ♀, 1–17. viii–ix. 1960 (R.R.D. 2443, 2542, 2546), 2 ♀ ♀, 10–14. iv. 1961 (R.R.D. 2664), 12 ♀ ♀, 2–24. iii–viii. 1962 (R. R. D. 2786, 2793, 2803, 2829, 2879) (F. R. I.). KERALA : Walayar Forests, 213.36m, 6 ♀ ♀, x. 1966, 1 ♀, P.S. Nathan, x. 1962, 1 ♀, P.S. Nathan, 213.30m 1 ♀, v. 1960, P. S. Nathan (OTTAWA), x. 1965, 2 ♀ ♀, P.S. Nathan (Gupta), 304.80 m, 1 ♀, ix. 1961, P. S. Nathan (Townes). KARNATAKA : Mercara, 1119. 20m, 1 ex (apex of abdomen broken), 14. xii. 1965, D. T. Tikar No. T134 (Gupta).

Distribution: India: Tamil Nadu, Kerala and Karnataka.

Host: Hapalia machaeralis defoliating *Tectona grandis.*

7. **Cremnops fuscipennis** (Brulle)

Agathis fuscipennis Brulle, 1846, *Hist. Nat. Insectes Hym.*, **4** : 493. Type ♂, Java (PARIS).

Cremnops fuscipennis : Szepligeti, 1908, *Notes Leyden Mus.*, **29** : 228.

Cremnops persimilis Szepligeti, 1908, *Notes Leyden Mus.*, **29** : 228. Type ♂, Java : Samarang (museum not given). New Syn.

This species is characterized by the characters given in the key.

8. **Cremnops nitidus** (Smith)

Agathis nitida Smith, 1858, *J. Linn. Soc. (Zool.)*, **3** : 26. Type ♂, Sulawesi : Makassar (Oxford).

Cremnops nitida : Baltazar, 1963, *Acta Hymenopt. Tokyo* **2**(1) : 2.

This species is recognized by having dark brown wings with a hyaline spot at the base of stigma and second intercubitus emitting a short vein. The entire body is covered with white pubescence.

Male : Face shiny, very sparsely punctate; face and clypeus 1.4 × as long as its maximum width; stipes long and densely pubescent; malar space 3 × the basal width of mandible and 0.7 × the eye height; vertex shiny and sparsely punctate; ocellar triangle raised, interocellar distance 0.55 × the ocello-ocular distance and 1.7 × the distance between median and lateral ocelli; mesoscutum shiny and sparsely punctate, its middle lobe raised with a median longitudinal carina, notauli distinct and transversely carinated; prescutellar depression with one longitudinal carina; scutellum smooth with weak lateral carinae; meso- and metapleurae shiny and sparsely punctate; ventral 0.5 of metapleurum with a few zigzag carinae, mesopleural furrow absent; submetapleural ridge blunt; basal and apical areas of propodeum with a few transverse carinae, apicolateral tubercles pointed; first and second intercubiti parallel, second intercubitus emitting a short vein, nervulus a little distad of basal vein; hind-femur 3.3 × as long as wide, longer hindtibial spur 0.5 × as long as hindbasitarsus; abdomen shiny and smooth, first tergite 1.4 × as long as its apical width, 2+3 trgites 1.3 × as long as wide, second tergite with a faint transverse groove.

Red and brown. Head, pronotum, mesoscutum, mesopleurum and forelegs red;

antennae, propodeum, abdomen, middle and hindlegs brown; wings dark brown, with a hyaline spot at the base of stigma, stigma and veins brown.

Female : Unknown.

Length : 8.1mm ; forewing 6.7mm.

Specimens examined : PHILIPPINE Is. : Cotabato, Aroman Exp. St., 2♂♂, 16 ii. 1953, Henry Townes (Townes).

Distribution : Philippines.

9. Cremnops collaris Ashmead (Figs. la, lb & 4)

Cremnops collaris Ashmead, 1904, *Proc. U.S.Natl. Mus.*, 28 :146. Type ♀, Philippines: Manila (Washington).

Cremnops collaris var. *semirufa* Roman, 1913, *Ark. Zool.*, 8(15) : 31. Type ♀, Philippines (Stockholm).

This species is characterized by having more than one hyaline spots in the forewing. The second intercubitus is without a short vein and body is covered with pubescence.

Female : Face shiny and sparsely punctate ; face and clypeus 1.2 × as long as its maximum width ; stipes moderately long (Fig.4) ; malar space 3-4.5 × the basal width of mandible and 0.6–0.8 × the eye height ; vertex shiny, sparsely punctate ; interocellar distance 0.4–0.45 × the ocello-ocular distance and 2 × the distance between median and lateral ocelli ; mesoscutum sparsely punctate, its middle lobe with a median longitudinal carina , notauli distinct and weakly transversely carinated ; prescutellar depression with one longitudinal carina ; scutellum smooth with lateral and apical carinae ; meso- and metapleurae sparsely punctate, mesopleural furrow absent ; submetapleural ridge blunt ; basal and apical areas of propodeum with a few transverse carinae, its apicolateral tubercles weak ; first and second intercubiti nearly parallel, second intercubitus without a short vein, nervulus distad of basal vein ; hindfemur 3.6 × as long as wide ; longer hindtibial spur 0.5 × as long as hindbasitarsus ; abdomen smooth first tergite 1.7 × as long as its apical width, 2 × 3 tergites 2 × as long as wide.

Red and brown. Head, pronotum, mesoscutum, scutellum, mesopleurum and forelegs red ; propodeum, metapleurum, middle and hindlegs and abdomen brown ; wings brown, veins and stigma brown, two to three hyaline spots in the forewing (Figs. la & lb).

Male : It is similar to the female but differs in the following characters : More pubescent specimens ; entire body dark brown except foretarsus and sternal plates of abdomen ; wings dark brown with usually one hyaline spot. Some males are having head and thorax red as in females.

Length : ♀, 8–9mm ; forewing 7–8mm. ♂, 8–8.5mm ; forewing 7mm.

Specimens exammind : 39 ♀♀, 55♀♀ PHILIPPINE Is. : Los Banos, 4♀♀, C.F.Baker (WASHINGTON; Los Banos, 4♂♂, 27. viii–xi. 1952-1953, Townes family (TOWNES), MANILA, 13♀♀ 2♂♂, Robtbrown (TOWNES), 1♀,1♂, (head broken), 10. i. 1953, 21. xii. 1952, Townes, family (TOWNES). MINDORO, 2♀♀ 16–19. iv. 1953, Townes family (TOWNES) ; Victoria, Alcate, 10♂♂, 5-11. iv.1954, H.M. & D. Townes (TOWNES). BILIRAN Is., 1♀, 1927, C. F. Baker (WASHINGTON). NEGROS: NEGROS ORIENTAL: Mt.v. Canlaon, 1097. 28mm, 7♀♀, 8♂♂, 2-30. iv-v, 1953, H. M. & D. Townes (TOWNES) ;Ley Tacloban, 7♀♀,8♂♂, 10-16.viii.1952, Henry Townes (TOWNES) ; Leyte, Utap, 2♂♂, 6–10. iv–xi. 1957-1958, Collectors name not given (TOWNES). Luzon : quezon Nat. Park, 335.28–609.60m, 2♂♂, v.1956, A. Concepcion (TOWNES) ; Cotabato, Aroman

Exp. St., 4♂♂, 16.ii.1953, Henry Townes (TOWNES) ; Calapan, San Luis, 45.72, 3♂♂, 13-14.iv. 1954, H. M. & D. Townes (TOWNES) ; Bontac, Iiong, Mt. Halcon, 914.40mm, 3♂♂, 27. xii. 1953, Townes family (TOWNES) ; Iiong, Mt. Halocon, 914.40mm 2♂♂, 6–18. iv-v. 1954, M. & D. Townes (TOWNES), Mt. Mayon, 1♂, 8.xii.1953, H. Townes Rosario, 1♂, 26.xii.1952, Henry Townes (TOWNES) ; Paawan, Pto. Princesa, 2♂♂ 12.xii. 1952, Henry Townes (TOWNES) Riz., Antipolo, 1♀, 27.vii.1952, Townes family (TOWNES).

Distribution : Philippines.

10. Cremnops kapilli, sp.nov.

This species is distinguished by having wide and stout abdomen, body with yellow pubescence and nervulus strongly distad of basal vein.

Female : Face distinctly punctate with sparse pubescence ; face and clypeus 1.4× as long as its maximum width ; stipes long ; malar space shiny, 3.6×the basal width of mandible and 0.7×the eye height ; vertex with a few punctures ; ocellar triangle raised, interocellar distance 0.5×the ocello-ocular distance and 2.5 × the distance between median and lateral ocelli ; meso-scutum rough, distinctly punctate, its middle lobe depressed with a median longitudinal carina, notauli distinct with small transverse carinae ; prescutellar depression with one longitudinal carina ; scutellum sparsely and distinctly punctate with thin lateral carinae ; meso- and metapleurae distinctly punctate ; submetapleural ridge prominent ; propode-um strongly carinated, basal and apical areas confluent with two transverse carinae, its apicolateral tubercles weak ; first and second intercubiti parallel, without emitting any short vein, nervulus strongly distad of basal vein ; hindfemur 3.2 × as long as wide, longer hindtibial spur 0.5 × as long as hindbasitarsus ; abdomen shiny and smooth, first tergite 1.4×as long as its apical width, 2–3 tergites 1.5×as long as wide, second tergite without any transverse impression.

Reddish-yellow. Scape, hindtrochanter, trochantellus, apex of hindtibia and tarsus brown ; wings dark brown with a hyaline spot at the base of stigma, veins and stigma dark brown.

Male : Unknown.

Length : ♀, 8.2 mm ; forewing 7mm.

Holotype ♀, PHILIPPINES : Cotabato, Pikit, 20.viii. 1953, Henry Townes (TOWNES).

Distribution : Philippines.

11. Cremnops bispinosa Szepligeti.

Cremnops bispinosa Szepligeti, 1905, *Annls. Hist. Nat. Mus. Natn. Hung.*, **3:** 51. Type ♂, Singapore (Lost).

This species is close to *C. modestus* (Smith) in the body colour and punctation but it can be distinguished by having dark brown wings with a hyaline spot and head being entirely yellowish. It can be distin-guished from *C. kapili* sp. nov. by having long and narrow abdomen and nervulus is weakly distad of basal vein.

Male and *female:* Face shiny, sparsely and distinctly punctate ; face and clypeus 1.4×as long as its maximum width ; stipes long with golden yellow pubescene ; malar space 3×the basal width of mandible and 0.65×the eye height; ocellar area raised, interocellar distance 0.5×the ocello-ocular distance and 2×the distance between median and lateral ocelli ; vertex with a few scat-tered punctures ; mesoscutum very sparsely punctate, its middle lobe depressed with a median longitudinal carina, notauli distinct with short transverse carinae ; prescutellar

depression with one longitudinal carina; scutellum smooth without any lateral or apical carinae; meso- and metapleurae very sparsely punctate, mesopleural furrow absent; submetapleural ridge prominent; propodeum strongly carinated, basal and apical areas with 4–5 transverse carinae, its apicolateral tubercles small and pointed; first and second intercubiti parallel without emitting any short vein ; (nervulus weakly distad of basal vein); hindfemur 3.5 × as long as wide, longer hindtibial spur 0.5× as long as hindbasitarsus; abdomen shiny and smooth, long and narrow, first tergite 2.2×as long as its apical width, 2–3 tergites 2×as long as wide, second tergite with a a faint impression.

Yellow. Antennae, abdomen, apices of hindtibiae and hindtarsal segments brown; wings dark brown with a hyaline spot at the base of stigma, basal 0.33 of stigma yellow and rest black.

Length: ♀,8.2mm ; forewing 7.2mm. ♂, 7mm ; forewing 6mm.

Specimens examined: HALMAHERA Is., ca 500m, 1♀, 1♂, 1965, A.M.R. Wegener (Ottawa).

Distribution: Halmahera and Singapore from literature.

12. Cremnops atricornis (Smith).

Agathis atricornis Smith, 1874, *Trans. R. Ent. Soc. London*, 1874: 398. Type ♀, Japan: Hiogo (London).

Bracon atricornis: Cartwright, 1933, *Circ. U. S. Dep. Agric.*, **289:** 7.

Cremnops atricornis: Fahringer, 1937, *Opusc. Bracon.*, **4** (4–6): 425.

Cremnops alterans Enderlein, (1918) 1920, *Arch. Naturgesch.*, **84** A(11): 185. Types ♀ ♂, Taiwan: Takao (Stettin).

This species has been reported from the Palaearctic, Nearctic and Oriental Regions. It can be recognized by having entire stigma brown, nervulus strongly distad of basal vein and forewing with only one hyaline spot at the base of stigma.

Female: Face rough, with very sparse pubescence; face and clypeus 1.0× as long as its maximum width ; stipes short ; malar space 5×the basal width of mandible and 0.7×the eye height; vertex shiny minutely punctate ; ocellar triangle raised, interocellar distance 0.6×the ocello-ocular distance and 2×the distance between median and lateral ocelli; mesoscutum sparsely and distinctly punctate, its middle lobe depressed, notauli distinct and smooth ; prescutellar depression with one longitudinal carina; scutellum smooth without any lateral or apical carinae ; meso- and metapleurae sparsely punctate with yellow pubescence, mesopleural furrow absent, submetapleural ridge prominent ; propodeum strongly carinated, its basal and apical areas with three transverse carinae, apicolateral tubercles weak ; first and second intercubiti almost parallel without emitting any short vein, nervulus strongly distad of basal vein ; hindfemur 4×as long as wide, longer hindtibial spur 0.5×as long as hindbasitarsus ; abdomen shiny and smooth, first tergite 1.5×as long as its apical width, 2+3 tergites 1.4×as long as wide, second tergite without a transverse groove.

Yellowish-red. Antennae, apex of hindfemur, apex of hindtibia and tarsus brown; wings dark brown, stigma and veins brown.

Length: ♀, 8mm ; forewing 6mm.

Specimen examined: TAIWAN : Sunmoon Lake, 1♀, 14.iv. 1969, M. Trap (TOWNES).

Distribution : Taiwan, Palaearctic and Nearctic from literature.

13. Cremnops posticeniger Enderlein.

Cremnops posticeniger Enderlein.

(1918) 1920, *Arch. Naturgesch.*, **84** A(11): 185. Type♂, Sumatra: Sukaranda (Warsaw).

This species can be recognized by the absence of a hyaline spot in the forewing and meso- and metapleurae, propodeum, abdomen and hindleg being dark brown. The interocellar distance is 0.33× the ocello-ocular distance and 1.0 × the distance between median and lateral ocelli.

Male : Face and clypeus shiny, very minutely punctate, 1.3×as long as wide ; stipes moderately long ; malar space 1.0× the eye height (mandibles broken) ; vertex smooth ; ocellar triangle not raised, interocellar distance 0.33×the ocello-ocular distance and 1.0×the distance between median and lateral ocelli ; mesoscutum shiny with a few punctures; notauli distinct and smooth; prescutellar depression broken ; scutellum shiny with a few punctures ; mesopleurum very minutely punctate, mesopleural furrow absent ; metapleurum strongly punctate ; propodeum strongly carinated, basal area long and apical area very short, apicolateral tubercles pointed, first and second intercubiti not parallel, second cubital cell not squarish and not emitting any short vein, nervulus distad of basal vein ; hindfemur 3.2 × as long as wide, longer hindtibial spur 0.5×as long as hind basitarsus ; abdomen shiny and smooth, first tergite 1.5×as long as wide, 2+3 tergites 1.6×as long as wide.

Dark brown. Head, pronotum, mesoscutum and scutellum yellowish-red ; fore- and middle legs yellowish-red ; wings dark brown without any hyaline spot.

Female : Unknown.

Length : ♂, 7.5mm ; forewing 7mm.

Specimens examined ; 2♂♂. SUMATRA : SUKARANDA, 1♂ (type of *C. posticeniger* Enderlein), 1919, H. Dohrn S. (WARSAW) ; 1♂, (cotype of *C. posticeniger* Enderlein), same data as the type (WARSAW).

Distribution : Indonesia: Sumatra.

14. Cremnops lemniscatus Enderlein.

Cremnops lemniscatus Enderlein, (1918) 1920, *Arch. Naturgesch.*, **84** A(11)9 184. Types ♀♂, Sumatra : Sukaranda (WARSAW)

This species can be distinguished by having basal 0.5 of wings yellowish-hyaline and apical 0.5 dark borwn with a brown stigmal spot reaching hinder end of the forewing. The mesoscutum is shiny and smooth, its middle lobe without any carina.

Male and *female:* Face and clypeus shiny, minutely punctate, 1.0×as long as wide ; facial tubercles pointed and separate ; malar space 3×the basal width of mandible and 0.7×the eye height ; stipes long; ocellar triangle not raised, interocellar distance 0.5×the ocello-ocular distance and 2×the distance between median and lateral ocelli; mesoscutum shiny and smooth ; notauli distinct and smooth ; prescutellar depression with one longitudinal carina ; scutellum shiny and smooth ; meso- and metapleurae shiny and smooth, mesopleural furrow absent ; propodeum moderately carinated, its apicolateral tubercles weak: first and second intercubiti not parallel, second intercubitus without any short vein, nervulus distad of basal vein ; hindfemur 3.5×as long as wide, hindtibial spur 0.5× as long as hindbasitarsus ; abdomen shiny and smooth, first tergite 1.5–1.7×as long as its apical width, 2+3 tergites 2×as long as wide.

Yellowish-red. Antennae, apical few tergites and apex of hindtibia and tarsus brown ; basal 0.5 of wings yellowish-

hyaline and apical 0.5 brown with a brown stigmal spot reaching hinder end of forewing.

Length : ♀, 8–8.5 mm; forewing 8mm. ♂, 8mm ; forewing 8mm.

Specimens examined : 5♀♀, 2♂♂. SUMATRA : SUKARANDA, 1♀ (type of *C. lemniscatus* Enderlein), 1919, H. Dohrn S. (WARSAW) ; 1♂ (type of *C. lemniscatus* Enderlein), 1919, H. Dohrn S. (WARSAW). NEPAL : LOTHAR, near Birganj, 4501 2♀♀, 1♂, 11–31. viii-ix. 1967 *Can. Nepal Exped.* (OTTAWA). INDIA : UTTAR PRADESH, Dehra Dun, 1♀, 8. vi. 1966, D.T. Tikar No T 213 (Gupta), Pindari collection, 1♀, G51 (Gupta).

Distribution : Sumatra, Nepal and India: Uttar Pradesh.

15. Cremnops malayensis, sp. nov.

This species comes close to *lemniscatus* Enderlein by having yellowish-red body, antennae and apex of hindtibia brown, nervulus strongly distad of basal vein but it can be separated by having distinctly punctate mesoscutum, its middle lobe with a median longitudinal carina and wings being light brown with three hyaline spots.

Female : Face shiny, minutely punctate ; face and clypeus 1.0×as long as wide ; stipes short ; malar space 3×the basal width of mandible and 0.7×the eye height; vertex shiny with a few punctures ; interocellar distance 0.5×the ocello-ocular distance and 2×the distance between median and lateral ocelli ; mesocutum distinctly punctate, its middle lobe with a longitudinal carina, notauli distinct and transversely carinated ; scutellum sparsely punctate ; meso- and metapleurae shiny with a few punctures, mesopleural furrow absent ; propodeum strongly carinated, basal and apical areas with three transverse carinae ; first intercubitus not parallel with the second, second intercubitus not emitting any short vein, nervulus strongly distad of basal vein ; abdomen shiny and smooth, first tergite 1.6×as long as its apical width, 2+3 tergites 2×as long as wide, second tergite with a distinct transverse groove.

Yellowish-red. Antennae, apex of hindtibia and hindtarsus brown ; basal 0.66 of wings hyaline and apical 0.33 of wings brown with a brown stigmal spot reaching hinder end of wing.

Male : Unknown.

Length : ♀, 7mm ; fore wing 6mm.

Holotype ♀, MALAY PENINSULA : LANGKAWI Is., West coast, 24.iv. 1928, H.M. Pendlebury (Gupta). **Paratype** ♀, same locality and collector as the holotype, 20. iv. 1928 (Gupta).

Distribution : Indonesia : Malaya.

16. Cremnops nigritarsis (Cameron)

Agathis nigritarsis Cameron, 1899, *Mem. Proc. Lit. Phil. Soc.*, **43:** 87. Type ♂, INDIA: KHASIA Hills (OXFORD). *Cremnops nigritarsis:* Baltazar, 1963, *Acta Hymenopt. Tokyo* **2** (1):2.

This species is distinguished by the characters given in the key.

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FIELD EVALUATION OF SOME INSECTICIDAL TREATMENTS FOR CONTROL OF COTTON STEM WEEVIL, *PEMPHERULUS AFFINIS* (FST)

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Field experiments were conducted on the control of cotton stem weevil *Pempherulus affinis* (FST) with MCU. 5 cotton using granular insecticides and spray formulation insecticides. The results revealed that a single soil application of any one of the granular insecticides aldicarb 10G, carbofuran 3G, disulfoton 5G or phorate 10G at 1.0 kg ai/ha one week after sowing around the plants or spraying four times on 15th, 30th, 45th and 60th day of sowing with fenvalerate 0.075 kg ha or monocrotophos 0.375 kg ha was effective in minimising the stem weevil infestation.

(*Key words :* **Cotton stem weevil, *Pempherulus affinis*, control**)

INTRODUCTION

Infestation by the cotton stem weevil, *Pempherulus affinis* (FST) is being noticed in certain tracts of Tamil Nadu. AYYAR (1940) has listed this as a major and serious pest of cotton in South India, next to bollworms. The pest activity is restricted to the early stages of the crop, but the symptoms of damage in the form of galls is noted on the stem only in the late stages. From 60 to 65 per cent of the cotton, *Gossypium hirsutum* variety MCU.5, a variety grown over a large area in Tamil Nadu has been reported to be infested by the stem weevil (THIRUMURTHY *et al.*, 1974; KAREEM *et al.*, 1977). SUBRAMANIAM & DAVID (1959) and DAVID *et al.* (1967) reported the efficacy of dieldrin and endrin spray and PARAMESWARAN *et al.* (1975) observed the efficacy of dieldrin spray and insecticide granules, in controlling cotton stem weevil.

The present paper reports the results of field trials undertaken at the Agricultural Research Station, Bhavanisagar, on the use of some insecticidal treatments for the control of the pest.

MATERIAL AND METHODS

A total of three experiments were conducted during 1976–77 and 77–78 winter seasons. In one of the two experiments undertaken during 1976-77 effect of certain granular insecticides and neem cake was assessed (Table 1) and in the second experiment relative effect of some insecticide sprays was studied (Table 2). The insecticide granules and neem cake were applied one week after sowing around the plants. The sprays were applied on the stem and in the soil around the plants with a knapsack sprayer four times at 15 days interval commencing from 15th day of sowing using 750 litres of spray fluid per hectare. Earthing up of the crop on 60th day of sowing in addition to the general earthing up done to all the treatment plots on 45th day of sowing, was also included as one of the treatments in the experiment of granules. In the third experiment, two granular insecticides and five spray formulations found effective in the other two tests were tested. Phosalone 0.65 kg/ha which was not tried earlier was also included in this test. In all the three experiments, the variety MCU.5 was used. The results were assessed in terms of per cent of plants showing stem galls ad yield as done by SUBRAMANIAM & DAVID (1959).

RESULTS AND DISCUSSION

In the case of insecticide granules all the four insecticides are significantly effective in controlling the stem weewil (Table 1).

TABLE 1. Effect of different insecticide granules, neem cake and earthing up on control of *P. affinis* and kapas production.

Insecticide and dose (ai/ha)	Stem weevil infestation (%)	Kapas yield in g/plot (22 sq m)	Yield (kg/ha)
Carbofuran 3G 1 kg	19.37 (11.0)	2612	1187
Aldicarb 10G 1 kg	19.49 (11.1)	2730	1240
Disulfoton 5G 1 kg	21.79 (13.8)	2612	1187
Phorate 10G 1 kg	20.46 (12.2)	2555	1161
Neem cake 500 kg/ha	27.01 (20.6)	2280	1036
Earthing up	29.34 (24.0)	1882	855
Control	29.93 (24.9)	1852	842
Significance	**	N S	
S E	0.59		
C D =0.05)	1.75	—	

Figures in parentheses are retransformed values to original scale (per cent).

TABLE 2. Effect of different insecticide sprays on control of *P. affinis* and kapas production.

Insecticide and concentration of spray (ai/ha)	Stem weevil infestation (%)	Kapas yield in g/plot (22 sq m)	Kapas yield (kg/ha)
Monocrotophos 0.375 kg	12.58 (4.7)	3715	1689
B H C 0.75 kg	17.77 (9.3)	2477	1126
Sevimol 0.75 kg	15.44 (7.1)	3227	1467
Fenvalerate 0.3 kg	10.84 (3.5)	6080	2764
Chlorpyriphos 0.375 kg	16.57 (8.1)	3052	1387
Mico–X 0.375 kg	16.87 (8.4)	2475	1125
Control (no insecticide)	28.36 (22.6)	2022	919
Significance	**	**	
S E	0.58	199	—
C D (P=0.05	1.72	592	

Figures in parentheses are retransformed values to original scale (per cent).

Neem cake and earthing up treatments were not effective in controlling the pest. But none of the treatments affects the kapas production significantly. All the insecticides used as spray are also significantly effective in controlling the weevil infestation (Table 2). Among the different insecticides, fenvalerate and monocrotophos are the most effective in reducing the infestation. Less effective are sevimol, chlorpyriphos and Mico-X which among themselves are on par. BHC is the least effective. As regards the kapas yield fenvalerate gives significantly higher yield than all other treatments. Monocrotophos, sevimol and chlorpyriphos also give significant increase in kapas over control. BHC and Mico-X are ineffective. Comparison of the selected insecticide treatments shows that significant control of the weevil is produced by sprays of phosalone, monocrotophos and fenvalerate and by granules of carbofuran (Table 3). Kapas production is significantly high with monocrotophos and fenvalerate but not with carbofuran. Aldicarb, however causes significant increase in kapas production. From

TABLE 3. Effect of some insecticide treatments on control of *P. affinis* (FST) and on kapas production.

Insecticide treatment (ai/ha)	Stem weevil infestation (%)	Kapas yield kg/plot (30 sqm)	Kapas yield kg/ha	Additional profit over control (Rs)
Aldicarb 10G 1kg	58.14 (72.1)	2.743	916	3310
Carbofuran 3G 1 kg	52.97 (63.7)	2.437	812	2628
Fenvalerate 0.075 kg S	50.57 (59.7)	4.987	1662	—
Monocrotophos 0.375 kg S	55.58 (68.2)	3.380	1127	4102
Chlorpyriphos 0.375 kg S	61.60 (77.4)	1.997	666	1760
Mico-X 0.375 kg S	61.05 (76.6)	1.087	362	—
Phosalone 0.65 kg S	49.85 (58.4)	2.037	679	1900
Control (no insecticide)	64.61 (81.6)	0.593	198	—
Significance	**	**		
S E	3.21	0.667		
C D (P=0.05)	9.76	2.020		

Figures in parentheses are retransformed to original scale (per cent).

G–Granules; S – Spray

the view point of cost benefit relation use of monocrotophos is the most profitable followed in the descending order by aldicarb, carbofuran, phosalone and chlorpyriphos (Table 3).

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INCIDENCE OF COTTON LEAF-ROLLER (*SYLEPTA DEROGATA* F.) ON DIFFERENT VARIETIES OF COTTON AND ITS CHEMICAL CONTROL

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Sylepta derogata (F.) **appeared in an epizotic form during September, 1976. Its incidence was more on** *hirsutum* **cotton and consequently, it was more serious on American varieties than** *desi* **cotton. The attack was more on early sown crop than the late sown crop. Of the 16 insecticides tested, azinphos-methyl, dicrotophos, chlorfenvinphos, dichlorvos, acephate, trichlorfon, fenitrothion, endosulfan, carbaryl and monocrotophos were effective for its control.**

(*Key words :* **Cotton leaf roller,** *Sylepta derogata*, **incidence, chemical control, cotton varieties)**

INTRODUCTION

Cotton leaf roller, *Sylepta derogata* (F.) is a sporadic pest of cotton in India (SOHI, 1964). Considerable damage by this pest to American cotton has been reported in the Punjab (HUSSAIN & BHALLA, 1937) and in Uttar Pradesh (LAL & SINGH, 1951). Application of DDT/BHC/endrin/parathion sprays or DDT and BHC dusts are recommended against this pest by many workers (LAL & SINGH, 1957; GUPTA & JOSHI, 1955; PATEL *et al.*, 1956; SRIVASTAVA, 1959; PATEL & PATEL 1962). SINGH *et al.* (1973) reported chlorfenvinphos, dicrotophos, tetrachlorvinphos, fenitrothion and monocrotophos to be effective against this pest. During 1976, this pest appeared in serious form on cotton. Observations were made on its incidence on different varieties and its chemical control.

MATERIALS AND METHODS

The incidence of leafroller was recorded on four varieties of American cotton (F 414, J 34, J 205 and 320 F) and two varieties of *desi* cotton (G 27 and LD 133). These varieties were sown in randomized lay out with 3 replications in plot size of 6×8 m. The incidence was recorded on basis of number of plants damaged, leaves rolled and larvae and pupal population on 10 plants in each plot. The observations were made in first and second week of September. Similar observations were made on J 205 and F 414 variety of American cotton sown on April 25, May 15 and June 15.

Two separate experiments were conducted on J 205 and F 414 variety of American cotton for its chemical control. The various insecticides tested are given in Table 3. The experiment was in randomized lay out with plot size of 6×8 m. Each treatment was replicated thrice. Only one spray was given in middle of September on F 414 and in end September on J 205 variety. The sprays were done with manually operated knapsack pump. The observations were recorded 2, 4, 7 and 14 days after spraying from 10 plants in each plot. In addition, 15 larvae were collected from each plot within an hour after spraying. These were reared in the laboratory on leaves plucked from respective plots from where the larvae were collected. Mortality among the larvae was recorded after 72 hours. In order to determine delayed effect, the larvae were reared up to pupation. The insecticides found promising in these two experiments were further tested in the laboratory to see how far their residual deposit can kill the newly emerged larvae. The larvae were obtained from the laboratory culture and were reared on cotton leaves having 2 and 7 days old spray-deposits. There were three replications of 15 larvae each. Data on larval mortality was

recorded after 3 days of feeding. Surviving larvae were reared till pupation to determine the delayed effect of different treatments.

RESULTS AND DISCUSSION

Incidence of cotton leafroller

The data on incidence of cotton leafroller on different varieties of cotton are given in Table 1. It was observed that number of plants damaged, leaves rolled and larval and pupal population was significantly less on *desi* cotton than American cotton. In the latter case it was maximum on J 34 and minimum on 320 F. The maximum number of damaged plants were in J 34 and there was no damage on LD 133. Similarly, there was an average 20 3 and 50 3 rolled leaves/plant on J 34 against nil in LD 133 on September 7 and 14, respectively. The larval and pupal population varied from 0 0 to 21.27 and 0 0 to 39.4 in the LD 133 and J 34 variety during these two observations, respectively. The data on the incidence of leafroller on J 205 and F 414 variety of American cotton sown in different period are given in Table 2. There was no difference in number of plants damaged in two varieties but number of leaves rolled and larval and pupal population was more on F 414 variety than J 205. The incidence, number of leaves rolled and population of leafroller was significantly different in the three sowing dates. The attack was high on early sown crop as compared to late sown crop during both observations.

Chemical control

The data on effect of various insecticides on mortality of cotton leafroller 2,4,7 and 14 days after spraying are given in Table 3. In the first experiment on J 205 variety of American cotton, 2 days after spraying the reduction in pest population varied from 39.5% (trichlorfon) to 99.2% (methadithion). There was no difference between methadithion, quinalphos, carbaryl and azinphos–

TABLE 1. Incidence of cotton leafroller on different varieties of cotton during 1976 (Average of 3 repeats of 10 plants).

Variety	September 7			September 14		
	Plants damaged	Leaves rolled	Larvae/ pupae	Plants damaged	Leaves rolled	Larvae/ pupae
A. American Cotton						
F 414	3.38c	19.3c	19.3/0.07d	4.3c	36.6d	19.6/2.0c
J 34	5.00d	20.3d	20.27/1.0d	4.2d	50.3e	27.1/12.3c
J 205	3.0c	17.5c	3.60/0.0.0b	3.3c	48.0b	11.0/0.3b
320 F	1.3b	8.0b	3.58/0.0c	2.3b	26.3c	22.9/1.0c
B Desi Cotton						
G 27	0.3a	0.3a	0/0a	0.0a	0.0a	0/0a
LD 133	0.0a	0.0a	0/0a	0.0a	0.0a	0/0a

Statistical analyses were done using $\sqrt{n+1}$ transformation ($p=0.05$)

TABLE 2. Incidence of cotton leafroller on F 414 and J 205 varieties of *hirsutum* cotton sown on different dates (Average of 3 repeats of 10 plants).

Parameters	September 7			September 14		
	plants damaged	Leaves rolled	Larvae+ pupae	Plants damaged	Leaves rolled	Larvae+ pupae
Variety						
J 205	6.65	62.73	22.09	7.67	100.80	61.15
	(2.58)	(7.92)	(4.70)	(2.77)	(10.04)	(7.82)
F 414	7.23	73.27	32.72	9.55	130.42	
	(2.69)	(8.56)	(5.72)	(3.09)	(11.42)	(9.98)
Date of sowing						
April, 25	0.36	223.31	79.21	9.99	223.80	152.2a
	(3.06)	(14.91)	(8.90)	(3.16)	(14.96)	(12.34)
May, 15	7.12	43.30	18.66	8.29	135.49	64.16
	(2.67)	(6.58)	(4.32)	(2.88)	(11.64)	(8.16)
June, 15	4.80	10.62	5.86	7.62	32.95	24.80
	(2.19)	(3.26)	(2.42)	(2.76)	(5.74)	(4.98)
C D (P = 0.05)						
Variety	NS	0.40	0.71	0.12	0.87	0.81
Date of sowing	0.28	0.49	0.58	0.15	1.06	0.99
Interaction	NS	NS	NS	NS	NS	NS

Figures in parentheses are $\sqrt{n+1}$ transoformations.

methyl. After 4 days of spraying the maximum control was observed with carbaryl (99.6%) and minimum with acephate (65.5%). All insecticides except acephate and endosulfan were equally effective after 7 days. Maximum mortality (89.8%) was observed in dichlorvos after 14 days of spraying and was significantly better than all other treatments. The minimum mortality was observed in quinalphos. In the second experiment, on F 414 variety there was significant difference among various treatments 2, 4 and 7 days after spraying but after 14 days all the insecticides were equally effective. Monocrotophos and dichlorvos gave the maximum mortality 2 days after spraying. Trichlorfon was least effective. Quinalphos, monocrotophos, leptophos, carbaryl, phenthoate, fentrithion and dichlorvos gave statistically equal kill of the pest 4 days after spraying. There was more than 95% control with carbaryl, leptophos, phenthoate and dicrotophos after 7 days of spraying. The least effective insecticide was acephate, killing 65.6% of the larvae.

Data on the delayed and direct effect of insecticide on mortality of cotton leafroller are given in Table 4. In the first experiment on J 205 the per cent mortality 72 Hours after spraying varied from 15.4%

TABLE 3. Comparative efficacy of different insecticides against cotton leafroller.

Insecticide	% reduction in larval population over control (after indicated days of spraying)							
	J 205				F 414			
	2	4	7	14	2	4	7	14
1	2	3	4	5	6	7	8	9
Phosalone 0.5 (Zolone 35 EC)	83.6cd	92.0bcd	94.2abc	43.0cde	66.6cd	67.0cde	94.8bc	20.8
Quinalphos 0.5 (Ekalux 25 EC)	93.6ab	86.9cde	91.3abc	25.1e	85.4ab	92.3a	86.9bc	9.4
Monocrotophos 0.5 (Nuvacron 40)	92.8bc	83.6de	95.3ab	69.5b	94.6a	86.0a	83.7cd	28.0
Leptophos 0.5 (Phosvel 34 EC)	85.0cd	93.0bcd	99.4a	54.7bcd	75.3b	88.8a	99.1a	18.2
Carbaryl 1.0 (Sevin 50 WP)	98.4ab	99.6a	99.3a	66.6bc	44.6cde	93.4a	100.0a	24.0
Phenthoate 0.5 (Phendal 50 EC)	87.4cd	98.1ab	89.4ab	41.7cde	66.2cd	81.3abc	98.1ab	36.3
Endosulfan 0.5 (Thiodan 35 EC)	87.0cd	94.2bcd	63.5c	65.3bc	NT	NT	NT	NT
Fenitrothion 0.75 (Folithion 50 EC)	88.3cd	84.6cde	87.4ab	61.0bc	72.0b	84.9ab	92.1bc	17.8
Trichlorfon 0.50 (Diptrex 50 EC)	30.5e	97.8ab	85.8abc	66.0bc	18.7e	70.3bcd	84.6cd	38.4
Acephate 1.0 (Orthene 75 WSC)	53.9e	65.6f	70.7bc	55.1bcd	30.4de	56.9de	64.6d	20.0
Azinphos-methyl 0.5 (Methyl continon 20 EC)	97.1ab	99.3ab	84.8abc	61.2bc	48.2cd	52.5de	88.1bc	20.8
Dicrotophos 0.5 (Bidrin 24 EC)	55.6e	84.6cde	94.7abc	61.2bc	51.3cd	70.6bcd	96.8abc	18.8
Chlorfenvinphos (Birlane 42 EC)	78.1cd	84.8cde	99.6a	58.8bcd	NT	NT	NT	NT
Dichlorvos 0.5 (Nuvan 40 EC)	91.8cd	99.0ab	97.6ab	89.8a	93.5a	84.6a	84.8bc	44.3
Fenthion 0.5 (Lebaycid 82.5 EC)	53.4e	75.0ef	92.9abc	36.1de	NT	NT	NT	NT
Methadithion (Supracid 50 EC)	99.2a	83.6de	86.1abc	68.2bc	NT	NT	NT	NT
Statistical significance (p=0.05)	S	S	S	S	S	S	S	NS

Statistical analysis was done using angular transformations.
NT = Not tested

TABLE 4. Efficacy of different insecticides in killing cotton leafroller larvae sown after spraying and due to delayed effect.

Insecticide kg ai/ha	% mortality after 3 days		% mortality due to delayed effect	
	J 205	F 414	J 205	F 414
Phosalone 0.5	65.1abc	55.6bc	10.9abc	20.0
Quinalphos 0.5	71.4ab	80.1abc	10.9abc	10.9a
Monocrotophos 0.5	75.6a	54.1bc	8.7ab	12.8a
Leptophos 0.5	67.4abc	49.0c	12.8abcd	19.7c
Carbaryl 1.0	80.4a	63.1abc	6.7a	15.4b
Phenthoate 0.5	73.5ab	50.4abc	5.7a	17.7bc
Endosulfan 0.5	71.4ab	NT	13.3bcd	NT
Fenitrothion 0.5	76.4a	54.2bc	15.4abcd	15.4b
Trichlorfon 0.5	54.1c	60.2abc	15.4bcd	20.2c
Acephate 1.0	60.0bc	51.2bc	20.0d	20.2c
Azinphos-methyl 1.0	76.0a	63.1abc	10.9abcd	17.4bc
Dicrotophos 0.5	64.6bc	65.2ab	12.8abcde	17.7bc
Chlorfenvinphos 0.5	66.7 abc	NT	12.6abcd	NT
Dichlorvos 0.5	63.1abc	71.4a	17.7d	15.4b
Fenthion 0.5	54.8c	NT	15.4bcd	NT
Methadithion 0.5	73.5ab	NT	12.8abcd	NT
Control	13.4d	10.8d	64.5c	69.0d

Statistical analysis was done by using angular transformation ($p = 0.05$)
NT = Not tested

in control to 80.4% in carbaryl. Except trichlorfon, fenthion, acephate and dicrotophos all were equally effective in killing the pest. There was least pupation in carbaryl and leptophos (6.7%) against 64.5% in control. In the second experiment on F 414, the mortality was 10.80% in control against 49.0% (leptophos) to 71.4% (dichlorvos) in treated plots. The per cent pupation varied from 10.9 to 69.0% and significantly less in monocrotophos and quinalphos, as compared to other insecticides.

The data on residual toxicity of different insecticides 2 and 7 days after spraying to newly hatched larvae are given in Table 5. The per cent mortality 3 days after spraying on 2 days old spray-deposit was significantly less in all the treated plot as compared with control. There was no difference among the various insecticides. The per cent pupation was nil in monocrotophos and 77.9% in control. Among the treated plot it was maximum in crbaryl (10.8%). The per cent mortality of newly hatched larvae 72 hours after spraying and their

TABLE 5. Mortality among first instar larvae of cotton leafroller having 2 and 7 days old spray deposit of different insecticides.

Insecticide kg ai/ha		% mortality after 3 days of spraying		% mortality due to delayed effect	
		2 day old deposit	7 day old deposit	2 day old deposit	7 day old deposit
Monocrotophos	0.5	95.1a	42.3a	0.0a	33.2a
Phosalone	0.5	75.9a	35.1a	0.8ab	43.8a
Quinalphos	0.5	73.5a	37.1a	0.0a	35.4a
Endosulfan	1.0	73.3a	33.2a	0.8ab	42 0a
Phenthoate	0.5	53.4b	28.4a	3.0a	49.5a
Trichlorfon	0.5	75.9a	35.5a	6.7bc	42.1a
Carbaryl	1.0	71.4a	35.3a	10.8c	46.7a
Control		17.4c	6 1b	77.9d	69 0b

Statistical analysis was done using angular transformations ($p = 0.05$)

pupation on 7 days old spray-deposit was significantly less in treated plots than the control. SINGH *et al.* (1973) tested monocrotophos, tetrachlorfenvinphos, dicrotophos endosulfan, fenitrothion and carbaryl and found them to be effective for the control of cotton leafroller. In the present studies also these insecticides gave effective kill of the pest.

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BIOLOGY OF THE GALERUCID, *OIDES SCUTELLATA* HOPE (COLEOPTERA : CHRYSOMELIDAE), A PEST OF GRAPEVINE

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Life history of the galerucid, *Oides scutellata* HOPE, recorded for the first time on grape vines, was studied at an average temperature of 25.0—28.5°C and 70—90 per cent RH. The insect has two generations on grape vines and the larva passes through three instars. Characters and duration of different post-embryonic stages are given.

(*Key words : Oides scutellata*, **life history on grape vine**)

INTRODUCTION

Comparatively few *Oides* spp. have been reported as pests; *O. affinis* JAC. was recorded on rice in India (FLETCHER, 1913) and Ceylon (JEPSON, 1924) while *O. collaris* BALY was noted as a noxious pest of maize and rubber in Germany and Africa (AULMANN, 1913; MORSTATT, 1913). On grape vines, on *O. decempuctata* BILLB. occurred as an established pest in China (HOFFMANN, 1932; LIU, 1941) and in India *O. bipunctata* has been registered feeding on wild grapevines (LEFROY, 1971). Although *O. scutellata* HOPE in Himachal Pradesh was collected by SHARMA & BHALLA (1964) from potato fields, yet its attack as a severe defoliator of grapevines was recorded only during 1976 at Solan. The present contribution on *O. scutellata* is a part of our research programme on the biology, seasonal history and control of this pest.

MATERIALS AND METHODS

The egg clusters and adult beetles were collected from the field and studies on post-embryonic development and behaviour were carried out in the laboratory at a temperature of 25.0–28.5°C and 70–90 per cent relative humidity. The eggs and the beetles were kept in glass jar covered with muslin cloth. Fresh grape leaves were supplied regularly as food. Prepupal movements and pupation were observed in small homeopathic vials filled with moist sand and wrapped in a black paper. Observations were recorded daily both in the laboratory and in the field.

RESULTS AND DISCUSSION

Adults

The amber coloured beetles are hemispherical with well developed prothoracic shield concealing the head. The filiform antennae are 11 segmented with slight serration in the basal segments. Female is slightly bigger than the male (♀ : 10.65 × 7.48 mm; ♂ : 10.11 × 7.15 mm.). The last few segments of its bulky abdomen get telescoped after egg laying. Secondly, in female the last sternal plate is entire (Fig. 1) against the two-notched in male (Fig. 2). In the laboratory, mating starts within a day after adult emergence. The male mounts the female, its aedeagus protrudes backwards, rotated through 180° and is inserted into the female's genital chamber. The copulation lasts for about 75 minutes. Multiple matings and cyclic ovipositions have been noticed. The duration between two subsequent egg depositions varies from 4–6 days and is some times even 8 days in

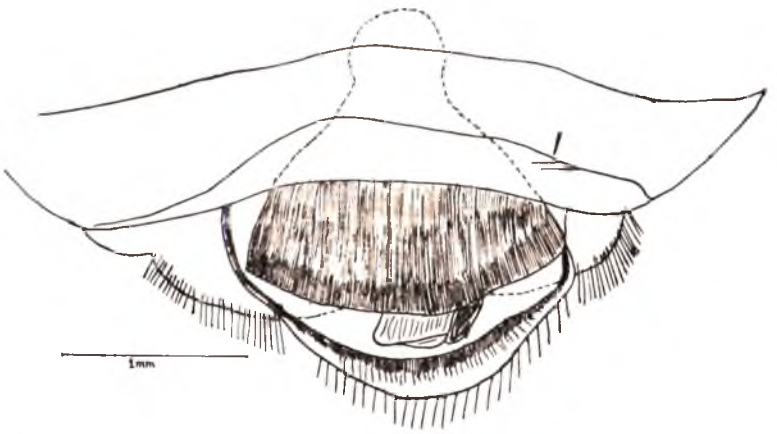

Fig. 1. Last abdominal segment (sternum) of female.

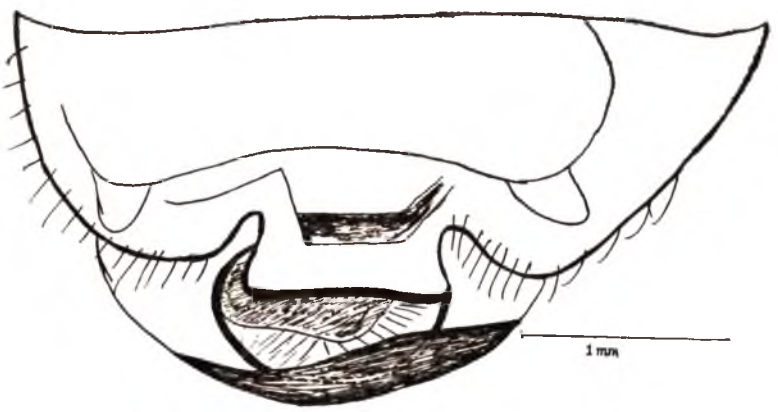

Fig. 2. Last abdominal segment (sternum) of male.

case of females which die comparatively earlier apparently due to some infection.

Beetles survive for a long time. Longevity of the female is greater than of the male. The female survives for 40–58 days while male lives for 35–42 days.

Eggs

The female explores a suitable place for oviposition and deposits eggs in cluster any where on the aerial parts of the vine, preferably on the under surface of the leaves and rarely on the upper surface. Freshly laid eggs are yellowish green in colour and easily separable but on exposure to air, get so firmly glued with one another that they become inseparable and their colour turns light brown to brown. The eggs in a cluster are held together in several layers by a cementing substance such that most of those are towards the periphery of the cluster. Cross section of a cluster reveals that on an average 15 out of 21 eggs are towards the periphery; while in the longitudinal section, 17 out of 24, are peripheral. The egg cluster is circular to oval and sometimes irregular in shape depending upon the place available for oviposition. The egg cluster on an

average measure 9.88 × 7.84 × 4.06 mm. The eggs on upper surface of the cluster are dome shaped, while those towards the substratum are polygonal, usually having hexagonal to quadrilateral margins. The variable shape of eggs in the cluster could perhaps be due to the pressure exerted by the closely packed adjoining eggs. There are 56–118 eggs in a cluster (average 84). Individual egg is oblong, measuring 1.20 × 1.03 mm. Hatching takes place between 12–15 days with a maximum hatch on the thirteenth day. On an average 65 larvae emerge from one egg cluster. A female is capable of ovipositing a maximum of 10 clusters with an average of 7 during her life time.

The Larva

The grub passes through three distinct phases of colouration. In the first instar larva the head is almost black and the trunk straw coloured. In second instar, the head turns light brown which is slightly darker than the creamy body. Head capsule appears lighter in third instar which has peculiar body colouration. The newly moulted larva is uniformly pale or straw coloured but within an hour, the colour gets changed. The change occurs first on prothorax and later extends to abdomen. The dorsum of the grub shows bluish-black while its venter is pale. The glistening gets lost with aging and late third instar grub has dull black dorsum.

The grub is orthosomatic and is not distinctly "C" shaped (Fig. 3). The antenna is small, two segmented and wrapped in a thimble like structure arising from antennal socket. The large proximal segment bears well developed sensory pegs and distal smaller segment is knob like. The larva has two ocelli, one on each side on the head capsule above the antenna. The labrum is free from cylpeus. Mandibles are palmate with five teeth, inner three with many proximal and fourth with poor fine saw like serrations. Maxillary palp is 3–segmented and the labial palp 2–segmented structure. Thorax possesses three pairs of legs, each with a terminal claw and a single pulvillus. Abdomen is ten segmented. The larva has 9 pairs of spiracles, first pair at the junction of pro- and mesothorax, appears to be mesothoracic in origin and rest one each on the first eight abdominal segments. Ventral to each spiracle is a

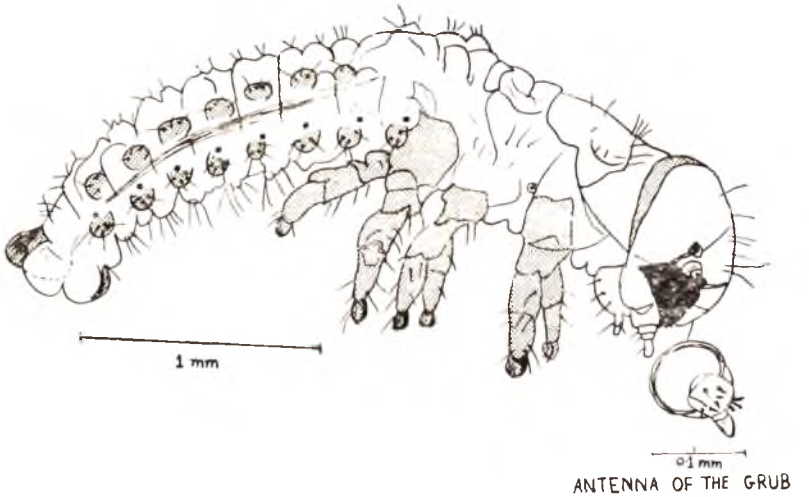

Fig. 3. First instar grub.

tubercle furnished with three sharp setae.

The full fed larvae of first, second and third instars measure 3.12×0.71, 8.58×2.12 and 14.63×4.12 mm respectively. Their average head capsule width is 0.650, 1.183 and 1.917 mm respectively, the average ratio for the observed width being 1.72. The development of respective instars completed in 5–7, 6–8 and 9–12 days thus total larval span was 20 to 27 days (Table 1).

The larvae in early stages prefer under-surface of tender laeaves for feeding and bit small holes. In the later stages, even the older leaves are eaten away leaving only the skeleton of veins on the vine.

Prepupa and Pupa

The full fed third instar larva becomes sluggish, its body shrinks and it enters the soil for pupation. The grub which has once entered the soil if disturbed, does not enter it again for pupation. Prepupal period lasts for 9 to 10 days. Pupation takes in a pupal cell made by pupating larva at a depth of 5 to 10 cm. The pupa measures 7.98×4.91 mm and the pupal period lasts for 11 to 12 days. The pupa is obtect, pale yellow with 8 pairs of lateral abdominal processes and a last pair of anal processes. The pupa appears to be sensitive to the soil moisture conditions. From the pupae, in almost dry soil, adults do not emerge. However, when they are placed on a wet filter paper, the adult emergence is normal. The newly emerged beetle cuts the pupal cell and wriggles out of the soil.

Seasonal history

The beetles are first observed feeding on grapevines during mid June and the egg clusters are noticed after about three weeks. The first generation is completed by early September when the beetles of second

TABLE 1. Dimensions and duration of various instars and stages of *Oides scutellata* HOPE.

Stage		Length (mm)	Width (mm)	Head size (mm)	Duration (days)
Egg		1.10–1.45* (1.22)	0.85–1.20 (1.03)	..	12–15
Larva:	First instar	2.80–3.40 (3.12)	0.66–0.73 (0.71)	(0.650)	5– 7
	Second instar	8.15–9.35 (8.58)	2.05–2.15 (2.12)	(1.183)	6– 8
	Third instar	14.10–15.25 (14.63)	3.60–4.60 (4.12)	(1.917)	9–12
Prepupa		..	..	..	9–10
Pupa		7.80–8.30 (7.98)	4.70–5.20 (4.91)	..	11–12
Adult:	Male	9.90–10.70 (10.11)	6.80–7.80 (7.15)	..	35–42
	Female	10.40–10.90 (10.55)	7.10–7.70 (7.48)	..	40–58

* Figures in parentheses are the average measurements.

generation start their activities on vines. Thus there are only two distinct broods during a year on grape vines. SHARMA & BHALLA (1964) have collected this beetle from potato fields and they have been also observed in the fields of maize. However, in our studies the beetles and the grubs are not found to feed on potato leaves or on those of the maize in the laboratory.

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METABOLIC RESERVES AND POOL SIZE OF FREE AMINO ACIDS DURING METAMORPHOSIS OF *CALLOSOBRUCHUS MACULATUS* (F.) (COLEOPTERA : BRUCHIDAE)

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At pupation of *Callosobruchus maculatus* (F.) .20 mg/mg and 25 μg/mg of the fresh body weight is composed of total lipids (TL) and glycogen respectively. Similarly, the conentration of free amino acid (FAA) pool is also at the peak (i.e. 105 μ moles/g fresh weight) during this period. In about 2.5 days of development TL are built up to the tune of .25 mg/mg, while both FAA and glycogen decrease. During mid and late pupal development, TL decline but glycogen remains constant. FAA pool increases around third day of development. On emergence both glycogen and FAA show a slight increase, whereas TL further decline.

(*Key words : Callosobruchus maculatus*, **free amino acids, metamorphosis).**

INTRODUCTION

The major ontogenetic events occurring during metamorphosis of insects are basically the manifestations of the process of cell differentiation. Amino acid metabolism along with the energy metabolism contribute to a great extent to this phenomenon. Therefore the study of free amino acids (FAA), glycogen and lipid contents is significant and can serve a useful purpose for an interpretation of the biochemical mechanisms occurring during the pupal-adult transformation.

MATERIAL AND METHODS

Callosobruchus maculatus were reared on *Cicer arietinum* at 32° C and 70% R H. It took 15 days for the initiation of pupation. Pupa in the pharate state lasted for 2 days and the dult emerged in 7 days.

For the determination of FAA pool various samples of pupae of known weight and age were homogenized in 80% methanol. The homogenates were spun at 6000 rpm for ten minutes, supernatants collected and evaporated to dryness. The dried masses were dissolved in ammonia free distilled water and FAA estimated by the method of TROLL & CANNON (1953). Glycogen and TL esitimated from various samples of known weight and chronological age according to SEIFTER *et al.* (1950) and FOLCH *et al.*, (1957) respectivly.

RESULTS AND DISCUSSION

The results of various estimations are presented in Fig. 1.

In the pharate pupa .20 mg/mg of fresh body weight is composed of TL. In about two and a half day of pupal development this value further increases to about .25 mg/mg. This increase in TL may slightly be due to the loss in body weight on account of the depletion of simple sugars and some carbohydrate reserves from the body but an increase of about 25% in TL in this short time can not be attributed entirely due to the loss in body weight and may be assumed that some actual increase in this metabolite takes place during this period. The high contents of TL in *C. maculatus* pupa corrsponds to the results achieved by COLLIN (1933) in *Pachymerus bactris* (Bruchidae),

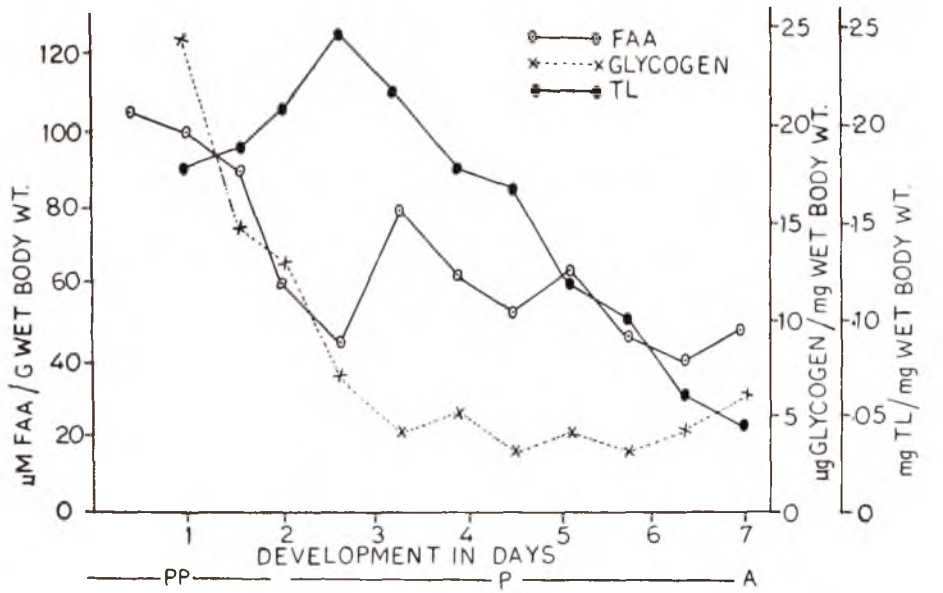

Fig. 1. Concentration of free amino acids (FAA), glycogen and total lipids (TL) during metamorphosis of *Callosobruchus maculatus* (F.)

TIMON-DAVID (1930) in *Acanthoscelides obtectus* (Bruchidae) & RAO & AGARWAL (1970) in *Trogoderma granarium*. The rise in TL during the early pupal period in the insect under present investigation however, is contrary to the results obtained by GILBERT (1967) in *Hyalophora cecropia* and LUDWIG *et al.* (1964) in *Musca domestica*.

During the same period there is a sharp decline in glycogen and FAA pool. Glycogen decreases from 25 µg/mg to 6.9 µg/mg, while FAA are reduced to half (Fig. 1). A decline in both these compounds when TL shows an increase (Fig. 1), suggests as if they are contributing to the accumulation of TL. DINAMARCA & LEVENBOOK (1966) in *Phormia* and CROMPTON & BIRT (1967) in *Lucilia* also reported the conversion of FAA to fatty acids and carbohydrates. But in the present study the decrease in FAA contents parallels to that of glycogen (Fig. 1), so it does not look plausible that the former is being transformed into the latter compound. It has also been noted that a sharp decrease in glycogen in concomitant with the event of puparium formation, which opens the possibility to argue that some amount of this compound might even be utilized in the synthesis of cuticular chitin. A similar likelihood was expressed by WRIGHT & RUSHING (1973) in stable flies, where a fall in glycogen was observed in the early pupal period.

During mid and late pupal development of *C. maculatus* the major portion of stored lipids is consumed. There is a continuous depletion of this metabolite as the development proceeds while glycogen reserves remain almost steady (Fig. 1). This indicates the metabolic significance of lipids as a major energy source during this period. MORAN (1959) reported in *Tenebrio* that fat and glycogen both furnish energy during metamorphosis, this observation seems to be quite true for the present insect as well, but here the role of glycogen is particularly significant during the first three days of pupal life while lipids act as the main energy

source in the later part. The contents of FAA do not undergo much variations in the late pupa. On emergence of the adult the glycogen increases slightly. While TL further decrease. FAA also registers an increase.

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BRIEF COMMUNICATION

STUDIES ON METABOLISM IN RELATION TO POST EMBRYONIC DEVELOPMENT OF SOME CALLIPHORID FLIES (DIPTERA : INSECTA)

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(Received 7 September 1978)

The close relation between the size of the species and their corresponding duration of growth and differentiation has been noticed in some selected fleshflies. Metabolic rates per unit weight were found to be much higher in all metamorphic stages of smaller species, viz., *Lucilia cuprina* and *Chrysomia megacephala* which showed a faster rate of growth and completed their life cycles earlier in comparison to the larger species, viz., *Chrysomia rufifacies* and *Sarcophaga ruficornis* which demonstrated a delayed developmental process and lower levels of metabolism.

(*Key words* : **Metabolism, development, calliphorid flies**)

Though studies on metabolic rate during the growth process forms a major topic of investigation in most of the physiological studies in insects, very few attempts have been made to examine the nature of relationship between size of the species, their corresponding duration of growth and differentiation and the rate of oxygen consumption in species concerned. Present attempt deals with this aspect.

A complex of fleshflies consisting of *Lucilia cuprina* WIEDEMANN, *Chrysomia megacephala* FABRICIUS, *Chrysomia rufifacies* MACQUART and *Sarcophaga ruficornis* FABRICIUS have been reared in the laboratory under controlled conditions of food, temperature and relative humidity. Overcrowding, parasitic infestation and other external agents were strictly prohibited from manipulating the growth process so as to obtain a strain of normal and optimum size.

Size of selected species was determined by measuring the length and maximum breadth in pupal stages and by measuring the maximum length of the wings in adult stages. Conventional Warburgh Respirometry was employed for studies related to oxygen consumption at 27°C in sequential post-embryonic stages of selected species. Growth rate of a particular species was adjudged on the basis of duration of differentiation in the present studies.

Size determinations clearly indicate that *L. cuprina* is the smallest species among the selected calliphorid group. The dimensions of other species vary in the following order : *C. megacephala* < *C. rufifacies* < *S. ruficornis*. The particulars regarding the parameters used and size measurements of pupal and adult stages have been presented in Table 1.

Metabolic rates per unit weight were found to be in relation to the developmental duration of species concerned. Thus, rate of oxygen consumption and growth rate were found to be in the order of *L. cuprina* > *C. megacephala* > *C. rufifacies* > *S. ruficornis*. Full particulars regarding duration of each metamorphic stage in all the species and pattern of oxygen uptake in all the post-embryonic stages have been presented in

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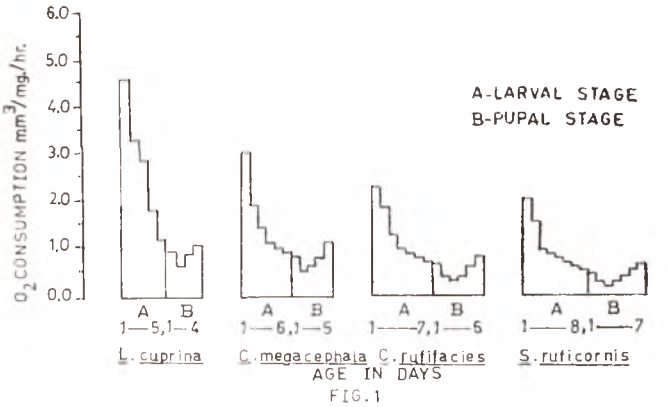

Fig. 1. Portrays oxygen consumption per unit weight in relation to growth rate (as indicated by days taken for completion of respective metamorphic stages) in larval and puapl stages of various species.

Fig. 1. The classical U-shaped metabolic curves were found to be more shorter and flatter in species with shorter duration of pupal stage.

According to AGRELL (1964) the difference in size between two given species is precisely due to difference in number of cells and not due to any average size of the single cell. The organisation in smaller species is constituted by smaller number of cells than in larger species which AGRELL (1964) believed to be responsible for completion of differentiation of smaller species at an earlier stage of growth than in larger species. Such size difference concomitant with earlier completion of life stages was quite evident in selected calliphorid species (See Table 1 and Fig. 1). *L. cuprina* and *C. megacephala* being the smaller among the studied species comparatively showed a faster rate of growth whereas the larger species *viz.*, *C. rufifacies* and *S. ruficornis* presented a prolonged life history.

It is established fact that energy requirements for growth are substantially greater than requirements for tissue maintenance and arrest of growth invariably results in low level of general metablism. (LEES, 1955; OKASHA, 1968). Cyclical changes in growth and respiration were observed in each of the larval instar of *Pyrrhocoris apterus* which are under the indirect control of hormonal processes (SLAMA, 1965). Energy expenditure in calliphorid larvae was generally found to decrease at a particular temperature with age (MEYER & SCHAUB, 1973). These attempts though, to a certain extent explain the specific trend of oxygen consumption during the growth period, they seem to have completely overlooked the possible relation between the developmental rate and oxygen uptake per unit weight of a given species.

The results obtained in the present attempt clearly indicate a definite correlation between the respiratory rate and duration of differentiation. Rate of oxygen consumption was found to be associated with accelerated growth processes. Endocrine secretions are known to control the post-embryonic growth and differentiation in both hemimetabolous as well as holometabolous insects (BODENSTEIN, 1953; WIGGLESWORTH, 1954). BODENSTEIN (1953) has further shown that amount of hormone available affects the growth rate of an organ or organism.

TABLE 1. Shows the dimensions of pupal and adult stages in different species.

Species	Pupal size (L. mm×B. mm)	Adult size (Length of the wing / mm)
L. cuprina	7.4×4.0	7.7
C. megacephala	7.5×4.0	8.3
C. rufifacies	9.0×4.0	8.5
S. ruficornis	10.0×4.0	10.0

Neurosecretion is also known to affect respiratory metabolism during growth and maturation (SLAMA, 1964a, b; 1965). It is quite evident from the above discussion that the interaction between species specific growth rate and quantity of hormonal secretion decides the developmental duration and rate of respiration. Also, the possibility of a need for greater work energy component during rapid development to fulfil the additional demands on energetic efficiency of insect growth to regularise increasing orderliness in body processes as the structure becomes more organised, looks all the more reasonable. The shorter and flatter U-shaped metabolic curves in species with shorter developmental duration during metamorphosis indicate the hastening of processes of histolysis and histogenesis for faster completion of life cycles in species concerned.

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BRIEF COMMUNICATION

GLYCOGEN AND TOTAL PROTEINS IN FLIGHT MUSCLES AND LATERAL SCENT GLANDS OF *TESSARATOMA JAVANICA* THUNBERG (PENTATOMIDAE : HEMIPTERA)

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The high content of glycogen in lateral scent glands of *Tessaratoma javanica* THUNBERG, is of the order of 952 μg/100mg, hence, a high value as campared to its flight muscles (561 μg/100mg), indicating carbohydrate metabolism The total protein content is 17% in lateral scent glands and 20% in flight muscles of *T. javanica*. In glandular cells of the scent glands, the greater need for protein synthesis has been stressed.

(*Key words :* **glycogen, proteins, flight muscles, scent glands, *Tessaratoma javanica***)

The hypodermal glands (scent glands) of insects produce not only pheromones but also chemicals which are used in defence (GORDON *et al.*, 1963). In *Nezara viridula*, GILBY & WATERHOUSE (1967) indicated the alkenyl acetates in the lateral scent glands. The electron microscopic structure of the lateral scent glands of *N. viridula* gave qualitative information on tracheation, high glycogen content and large number of mitochondria (FILSHIE & WATERHOUSE, 1968). Insect flight muscles contain high content of glycogen and total protein (CHARI, 1970). However, there is a paucity of literature on the glycogen and protein content in lateral scent glands and flight muscles of *T. javanica*. Therefore, in the present study, the glycogen and protein contents have been reported.

T. javanica is commonly found on the soapnut tree, *Sapindus emarginatus* VAHL. (Fam: Sapindaceae). Adult males and females were maintained on fresh young leaves of the host in the cage for 2–3 weeks at room temperature. The dorsal longitudinal pterothoracic flight muscles and lateral scent glands of *T. javanica* have been used. In the case of lateral scent glands fifty insects were sacrificed. For glycogen estimation the procedure was similar to the modified anthrone method (KLICPERA *et al.*, 1957). The protein estimation was done by the method of LOWRY *et al.* (1951). The values of glycogen and protein have been expressed in μg/100 mg wet weight and mg% respectively.

A perusal of Table 1 shows that the lateral scent gland/flight muscle ratio is of the order of 1.6 and this indicates a high content of glycogen and a reserve source of carbohydrate used in aerobic and anaerobic metabolism. KUBISTA (1958) was the first to suggest that high amount of glycerophosphate formation corresponds to half the amount of glycogen broken down, pyruvate and acetate also accumulate. The electron microscopic studies of lateral scent glands of *N. viridula* indicated the presence of large amount of glycogen, lipid droplets, mitochondria and rich tracheation (FILSHIE & WATERHOUSE, 1968). No correlation has been shown either in the flight muscles or in the lateral secent glands of *T. javanica* between the high content of glycogen and large number of mitochondria and rich

TABLE 1. Glycogen and protein contents in *T. javanica*.

Tissue	Glycogen content μg/100 mg	Protein content mg/100 mg
Flight muscle (n = 4)	561 ± 50	20.20 ± 0.77
Lateral scent glands (n = 2)	952 ± 20	16.95 ± 1.85

tracheation. It is quite possible as in insect flight muscles that this high amount of glycogen in the lateral scent glands may give rise to glycerophosphate as a product of glycolysis and this can be further oxidised by large number of mitochondria. GORDON *et al.* (1963) incorporated ^{14}C–acetate, the main building unit of lipid mtabolism, into the scent constituents of *N. viridula*. The high amount of glycogen coupled with large number of mitochondria, tracheoles and lipids in the lateral scent glands of *T. javanica* appear to suggest in favour of glycerophosphate formation.

The protein content is variable in different tissues. In *T. javanica*, the flight muscles contain 20% and lateral scent glands 17% respectively. It has to be emphasised that the lateral scent glands have considerable amount of chitinous intracellular and intercellular canals, hence, the protein content calculated on the basis of wet weight appears less as compared to its flight muscles. The present authors (VENKAT REDDY *et al.*, 1976) reported endopolyploidy and high amount of DNA content in the scent glands. The relative high amount of protein in the lateral scent glands may lend further supporting evidence to this concept.

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DEVELOPMENTAL MORPHOLOGY OF THORACIC APPENDAGES OF *ASCHISTONYX CRATAEVAE* (MANI) (DIPTERA : CECIDOMYIIDAE)[1, 2]

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(Received 20 June 1978)

The developmental morphology of the thoracic appendages has been traced in *Aschistonyx crataevae*. A description of the structure and location of their respective imaginal buds at the onset of pupation and progressive transformation of these buds into fully formed appendages has been given in the present study.

(*Key words* : **developmental morphology, thoracic appendages, gall midge,** *Aschistonyx crataevae*)

INTRODUCTION

Though the development of the thoracic appendages in Cyclorrhaphous Diptera has been studied in some detail by workers like CHEN (1929), AUERBACH (1936), ROBERTSON (1936), WADDINGTON (1939), BODENSTEIN (1950) and IPE (1971), no detailed study of this nature has been carried out in Nematocerous Diptera, more so in Cecidomyiidae. The present investigation on the developmental morphology of the thoracic appendages in *Aschistonyx crataevae* (MANI), a gall midge forming galls on flower buds of *Crataeva religiosa* FORST, was undertaken with a view to provide this much needed information. The description of developmental changes during pupation is given under three main stages: early (35 hr), middle (72 hr) and late pupal (135 hr). The pupal duration is approximately 136 hrs at 35–38°C and 36–39 % RH.

[1] Contribution No. 249 from the School of Entomology, St. John's College, Agra.

[2] Part of work approved for the degree of Ph. D. in the University of Agra.

MATERIALS AND METHODS

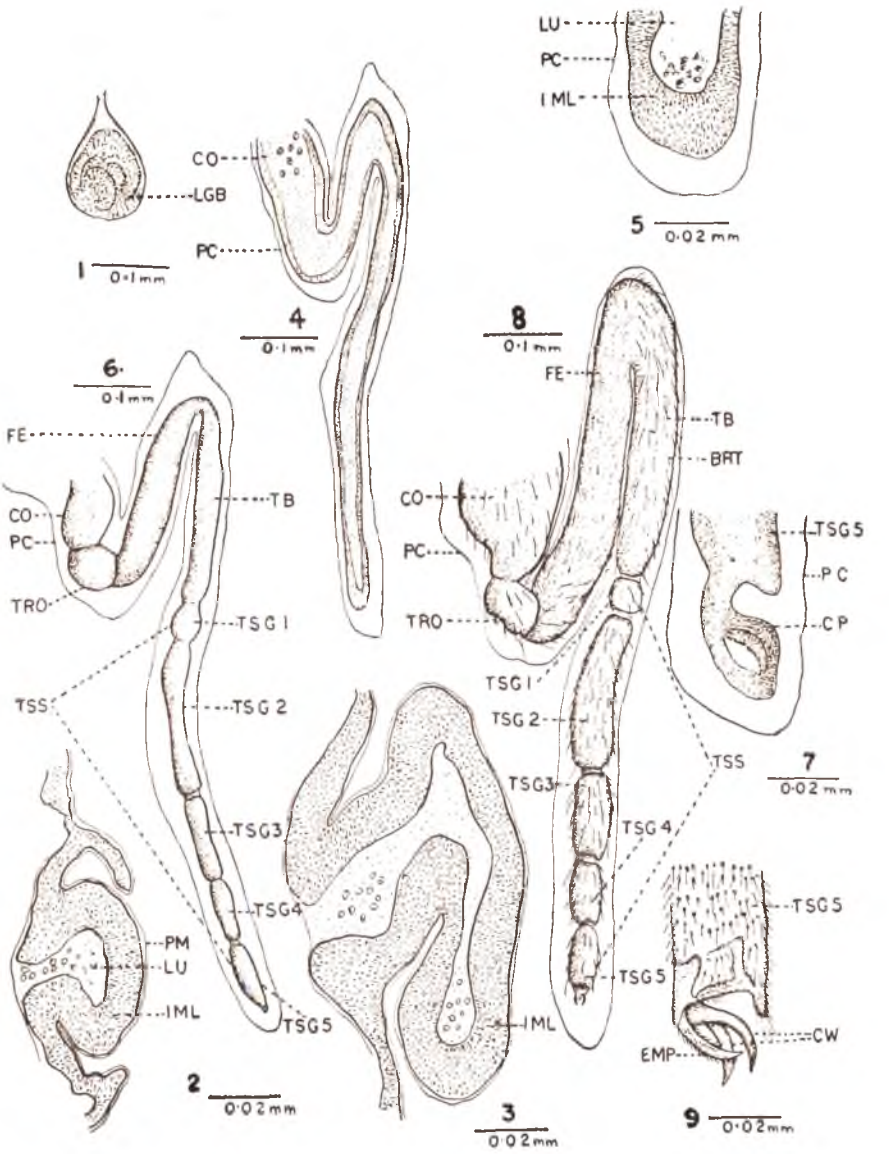
The study was carried out by micro dissecting the buds and preparing whole mounts from both fresh and fixed material at various stages of pupal development. The fresh mounts were made in glycerine whereas permanent preparations were mounted in Canada Balsam. Illustrations were drawn with the help of camera lucida. Techniques utilised for rearing and microtomy are similar to those given by the author in an earlier paper (USHA SHARMA, 1977).

RESULTS AND DISCUSSION

The development of the thorax and its appendages in *Aschistonyx crataevae* involves the development of a pair of wings, three pairs of legs and a pair of halteres. The wings, halteres and legs are represented in the immediately formed pupa by their corresponding buds situated in the thoracic segments. The imaginal buds of these appendages though clearly visible in the second and the third instar larvae of *D. melanogaster* (BODENSTEIN, 1950), are not visible even in the last instar larva in *A. crataevae*.

Location of the imaginal buds at the onset of pupation

The three pairs of leg buds are situated in the mesometathoracic segments of the last



Figs. : 1. Early leg bud; 2. L. S. of early leg bud; 3. L. S. of proliferating leg bud; 4. Leg early pupal stage (Whole mount); 5. Leg tip early pupal stage (enlarged); 6. Leg mid pupal stage (whole mount); 7. Leg tip mid pupal stage (enlarged); 8. Leg late pupal stage (whole mount); 9. Leg tip late pupal stage (enlarged).

ABBREVIATIONS USED

BRT–Bristle; CO–Coxa; CP–Conical projection; CW–Claws; EMR–Empodium; FE–Femur; IML–Imaginal; LGB–Leg Bud; LU–Lumen; PC–Pupal cuticle: PM–Peripodial membrane; TB–Tibia; TRO–Trochanter; TSG 1-5–First to fifth tarsal segments; TSS–Tarsus.

instar larva at the onset of pupation. The leg buds are ventrolateral in position and lie in a straight line on either side of the brain.

The wings arise from a pair of dorsal mesothoracic buds. They are clearly visible in the immediately formed pupa and overlap the second pair of leg buds. The halteres develop from a pair of dorsal metathoracic buds. The haltere buds lie in close approximation to the third pair of leg buds.

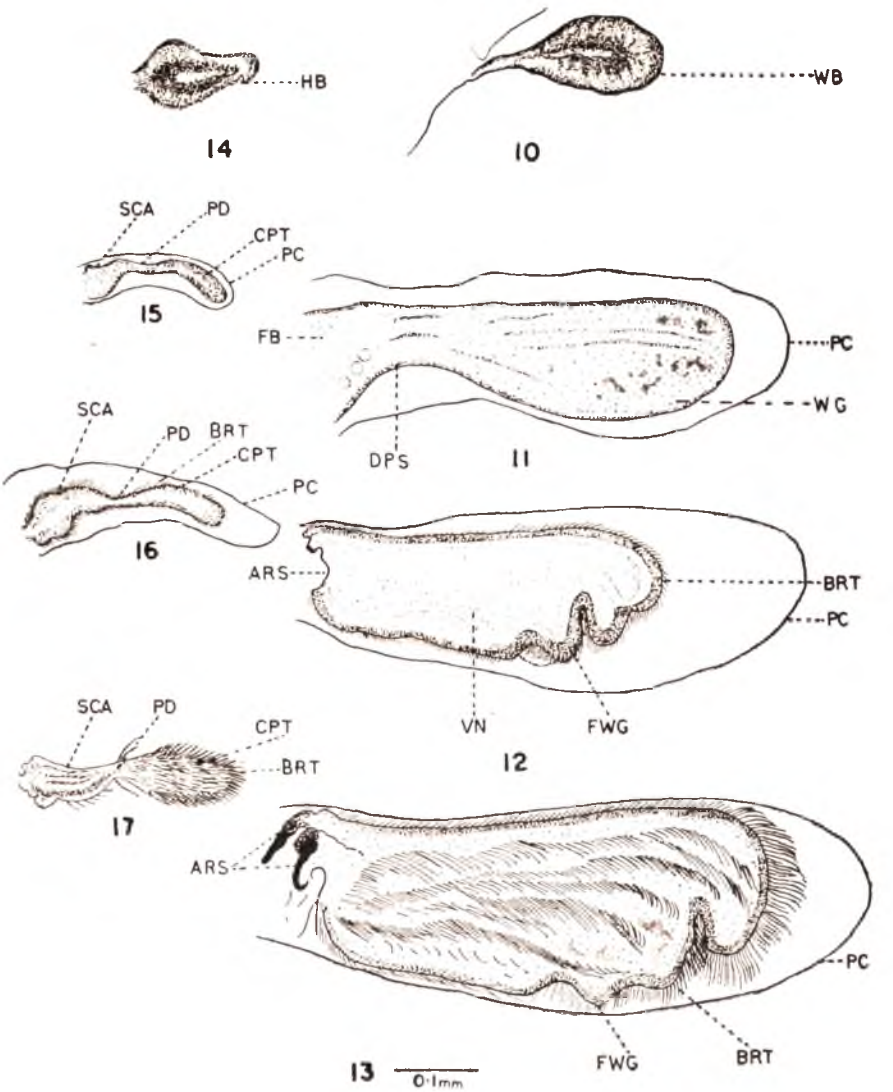
The onset of pupation in *A. crataevae* is recognisable externally by the divergence of eye spots in larvae placed for pupation.

Development of the leg

An early leg bud (Fig. 1) is ovoid in shape and consists of an invagination of a thickened ectodermal area of imaginal cells (Fig. 2) surrounding a lumen called the peripodial cavity and covered externally by a thin peripodial membrane. The imaginal layer is composed of closely packed, deeply staining elongated cells with distinct nuclei, staining deep red with Mallory's triple stain. The peripodial cavity is filled with loosely packed round cells. A space between the peripodial membrane and the leg bud known as peripodial space is clearly visible. Progressive growth of the leg bud involves further lengthening of the imaginal cell layer and consequent deepening of the peripodial cavity (Fig. 3). BODENSTEIN (1950) in *D. melanogaster* observes that the traces of later leg segmentation are clearly visible in the developing imaginal buds. He further reports a telescoping of various leg segments and states that the telescoped segments become exposed, and at a stage five tarsal joints as well as the tibia and femur are clearly seen in the imaginal bud. The corresponding development of the leg in *A. crataevae* proceeds in a manner different to this, no traces of segmentation were recognisable in the imaginal bud, the telescoping of leg segments and their exposure is not visible. The leg develops by terminal proliferation of the imaginal bud and signs of its segmentation are visible only during the midpupal stage. The first, second and third pair of leg buds differ very little from each other during further development. The second and third pair of leg buds presumably unfold earlier than the first pair of leg buds, as they are elliptical in shape and are also longer in size than the first pair. Towards the latter part of the early pupal stage the developing leg, (Fig. 4) an elongated structure bent upon itself twice, loosely ensheathed in a fine transparent pupal cuticle is completely everted and shows a marked resemblance to the adult leg by the manner in which it is folded. The developing leg does not exhibit any segmentation at this stage, but the formative coxa can be recognised in its broad proximal end. The leg wall is composed of a fairly thick columnar layer of imaginal cells, compactly arranged. The cells stain deeply and possess conspicuous nuclei. The lumen of the leg is narrow and packed with round cells. The tip of the leg (Fig. 5) is composed of a solid core of cells at this stage.

By the midpupal stage the leg (Fig. 6) assumes the shape of a typical adult leg. The developing leg is still ensheathed in the transparent pupal cuticle, but the space between the cuticle and the leg has widened because of the contraction of the leg. The leg segments are clearly recognisable in this stage.

The stout coxa marked off from the trochanter shows musculature within. The tibia is as long as the femur but not as stout. The tarsus is five jointed, the first tarsal joint is the shortest, while the second is the longest the third, fourth and fifth tarsal segments are nearly equal to each other in length. The terminal tarsal segment has a



Figs. : 10. Wing bud; 11. Wing early pupal stage; 12. Wing midpupal stage; 13. Wing late pupal stage; 14. Haltere bud; 15. Haltere early pupal stage; 16. Haltere midpupal stage; 17. Haltere late pupal stage.

ABBREVIATIONS USED

ARS–Articulation surface; BRT–Bristles; CPT–Capitellum; DPS–Depression; FB–Fat body; FWG–Folded wing; HB–Haltere bud; PC–Pupal cuticle; PD–Pedicel; SCA–Scabellum; VN–Vein; WB–Wing bud; WG–Wing.

conical prolongation (Fig. 7), the precursor of the claw and empodium. At this stage the leg shows signs of sclerotisation. The imaginal cell layer is reduced to an epithelium and a fine cuticle has been secreted. The lumen of the leg has narrowed considerably and is traversed by muscles in the region of the coxa femur and tibia, visible clearly through the transparent cuticle. The leg is covered externally by fine, colourless, weekly sclerotised bristles.

In the late pupal stage (Fig. 8) the leg is more or less fully formed and resembles an adult leg except for the degree of sclerotisation. It is still ensheathed in a transparent pupal cuticle. The coxa is short and stout, the well defined trochanter is ring like, a stout long femur, shows well developed musculature within. The bristles clothing the femur are better sclerotised. The tibia, nearly as long as the femur is not as stout, it is also clothed with sclerotised brown bristles. The five tarsal segments are also clothed with bristles. The fifth tarsal segment (Fig. 9) bears the claws which are well sclerotised. An empodium is also clearly formed. The leg at this stage is loosely ensheathed in the pupal cuticle and undergoes further sclerotisation till emergence.

Development of the wing

The development of the wing in *Aschistonyx ctataevae* follows the usual pattern of wing development in Cyclorrhaphous Diptera (AUERBACH 1939; BODENSTEIN 1950). The wing bud (Fig. 10) is somewhat oval is shape, and has a short stalk which attaches it to the hypoderm. The neural connection of the bud could not be seen. The anterior portion of the bud contributes towards the formation of the hypoderm of the thorax, whereas the posterior portion forms the wing proper. The bud, a compact mass of imaginal cells at this stage, is surrounded by a fine peripodial membrane. The peripodial cavity is distinct. Posterior portion of the bud forming the wing proper shows characteristic ridges and folds.

As development of the wing proceeds further, a terminal proliferation of the bud is observed. By the early pupal stage the wing appears as a thin walled flap like structure (Fig. 11). The proximal part of the wing contains fat body and is separated by a slight depression from the broad distal part. The wing shows the beginning of vein formation, as a clear streak in the middle of the expanded wing. The wing margin is smooth and the whole wing is ensheathed in a fine transparent pupal cuticle with very little intervening space between the ensheathed wing and transparent pupal cuticle at the distal end.

By the midpupal stage the sac like wing (Fig. 12) has contracted considerably and the venation has become more clearly established. The proximal end of the wing shows the beginnings of the development of the articular surface of the wing. The wing surface is folded along the lower margin in a characteristic manner and the wing bears delicate transparent unpigmented bristles. The wing venation is clearly recognisable and the veins appear as tubular regions. The costa, radius and the cubitus are clearly visible. Externally the wing is loosely ensheathed in a transparent pupal cuticle and a wide space caused by folding of the wing separates the wing from the pupal cuticle, at its distal end.

The wing in the late pupal stage (Fig. 13) increases in size and acquires a slightly yellow colour changing into pale brown due to the pigmented bristles and hair clothing the wing surface. The venation of the wing though more marked is obscured by the hair which cover the entire surface and margins. It is still folded along its lower margin, but its proximal end has differentiated

further for articulation. The wing is now thin and delicate and bears a great resemblance to the adult wing, further sclerotisation of the wing takes place before its unfolding at emergence. The entire wing is still ensheathed in the transparant pupal cuticle.

Development of the haltere

The development of haltere in *Aschistonyx crataevae* is more or less similar to that of the wing in its earlier stages. The haltere bud (dorsal metathoracic bud), smaller than the wing and leg buds, is clearly visible at the onset of pupation. It is oval in shape, has a thick imaginal layer, and is surrounded by a fine peripodial membrane (Fig. 14). The haltere develops by a proliferation at the distal end of the bud which elongates. It is rounded apically and broader basally.

In the early pupal stage the haltere elongates and becomes flap like and by the latter part of the early pupal stage (Fig. 15) it distinguishes itself into a basal region and a distal elongated region. The narrow intermediate portion is the stalk or the pedicel. The distal region differentiates into the capitellum. The lumen of the capitellum is narrow and the imaginal cell layer is thick. The haltere at this stage is narrow and elongated as compared to the early broad leaf like stage.

By the midpupal stage the haltere (Fig. 16) has distinguished itself distinctly into the scabella, pedicel, and capitellum and is clothed by fine transparent filamentous bristles. It is still ensheathed in the pupal cuticle.

The haltere nearly fully formed by the late pupal stage (Fig. 17) is reduced to a thin transparent structure, and has become more or less oar shaped. Its component regions have attained their characteristic shapes. The capitellum bears bristles which are faintly sclerotised. The pedicel and the scabella are distinctly separated by sclerotised folds. The haltere still ensheathed in the fine transparent, coloureless pupal cuticle is overlapped and completely concealed by the wing, at this stage.

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A NEW SPECIES OF THE *TAKAHASHII* SUBGROUP OF GENUS *DROSOPHILA* (DIPTERA : DROSOPHILIDAE)

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A new species *Drosophila jagri*, a member of the *takahashii* subgroup of the *melanogaster* species group, collected from Western Ghats is described. The taxonomic status and relationships are discussed.

(*Key words*: *Drosophila jagri*, **new species**, *takahashii* **subgroup**)

Western Ghats harbour numerous and diverse species of the genus *Drosophila*, many of which are still undescribed. The *Drosophila* fauna of this region contains a majority of species belonging to either *melanogaster* or *immigrans* species group (Prakash and Sreerama Reddy, 1978). Recent collections of *Drosophila* in Jagra valley, near Muthodi about 40 km to the west of Chikmagalur (a part of second phytogeographical region of Western Ghats), have yielded several known species in addition to a new species, *Drosophila jagri*, which is herein described.

Drosophila jagri sp. nov.

Male and *female*: Bright yellow. Abdomen of male apically black. Mean body length, males 2.1 mm; females 2.4 mm.

Head, ♂ and ♀ : Arista with 9 branches (5/4) including terminal fork. Front brownish yellow in male, dark brown in female. Antenna light yellow. Cheeck with 2 medium sized vibrissae along with number of smaller ones. Palpi pale yellow. Carina narrow. Eyes orange red. Anterior orbitals same size as that of the posterior orbitals, middle half the size of the anterior. Inner and outer verticals are of same size and reclinate. Ocellar triangle small, brownish, with two long ocellar bristles.

Thorax, ♂ and ♀ : Brown. Acrostichal hairs in 8 rows, regularly placed. Anterior dorsocentrals three-fourth the posterior. Scutellum light brown. Anterior scutellars convergent, posterior scutellars larger than the anterior and crossed. Posterior sternopleurals largest, anterior sternopleurals half the size of the posterior. In addition to small middle sternopleurals, 4 to 5 much smaller bristles are also present.

Wings, ♂ and ♀ : Slightly dusky. Wing lengths: ♂ 1.9 mm; ♀ 2.2 mm. Halteres small yellowish. Approximate indices: Costal index 2.1; 4V index 2.3; 4C index 1.3; and 5X index 2.6.

Legs : Preapical bristles on all tibiae; apicals on first and second tibiae. Sex-comb of male (Fig. 1) in transverse rows of stout black bristles; two to three metatarsal rows of (from above down) 0–1, 2–4, and 3–5 teeth; and three to four rows on the second tarsal segment of (from above down 0–2, 1–2, 2–3 and 2–3 teeth.

Periphallic organs, (Fig. 2): Epandrium (Genital arch) dark above, light below, borad laterally with a median dorsal

Drosophila jagri sp. nov. : Fig. 1. Foreleg of male showing sex-combs.

constriction. Toe elongate and narrow with 7–8 bristles. Primary surstylus (primary clasper) only present, large, with 5 sets of teeth—dorsolaterally with 2 black teeth; ventrolaterally with a comb of 5–6 long black teeth; dorsomedially with a row of 3–4 well spaced pointed ventrally recurved bristles; ventromedially with 1–2 thin black dorsally recurved bristles; and between these and the ventrolateral comb (on lower border of surtylus) 3–4 dusky, basally broad and apically pointed teeth. Cerci (anal plate) with long fine bristles above, and a cluster of smaller bristles below.

Phallic organs (Fig. 3): Aedeagus bare, apically rounded; basal apodeme long. Anterior gonapophyses (anterior parameres) large, crescentic, apically pointed, distally black. Posterior gonapophyses (posterior parameres) large, apically round with basal branches sclerotized and marginally serrate. Novasternum with lateral conical expansion bearing sensilla and a pair of submedian spines on caudal margin.

Egg guide (Fig. 4): Pale brown, with about 13 teeth and a subterminal hair.

Internal structures : Testes yellow, with about 4 outer and 2–3 inner coils. Accessory glands large and transparent. Ejaculatory bulb globular (Fig. 5). Spermathecae bell shaped, snuff coloured, paraovaria ovoid. ventral receptacle tightly coiled (Fig. 6). Malpighian tubules 2 pairs, free.

Egg filaments (Fig. 7) : 2 long slender filaments, slightly flattened apically.

Pupae : Anterior spiracles with about 8–9 branches.

Chromosomes : Male metaphase plate consists of 2 pairs of V's, a rod shaped X-chromosome, and a short Y.

The species can be cultured in the laboratory. The progenies obtained were used for the analysis of wing indices and other morphological characters.

Holotype ♂, INDIA : WESTERN GHATS : Karnataka : Jagra valley, 8. ix. 1977. Coll. H. S. Prakash and G. Sreerama Reddy. Deposited in the museum of Department of Zoology, Manasa Gangotri, University of Mysore, Mysore. **Allotype** ♀, data as above. **Paratypes :** 10 ♂♂ and 10 ♀♀, INDIA : WESTERN GHATS : Karnataka : Jagra Valley, Coll. H.S. Prakash and G. Sreerama Reddy. Deposited in the Department of Biology, Tokoyo Metropolitan University, Setagaya-ku, Tokyo, Japan and some will be deposited in Zoological Survey of India, Calcutta and Indian Agricultural Research Institute, New Delhi.

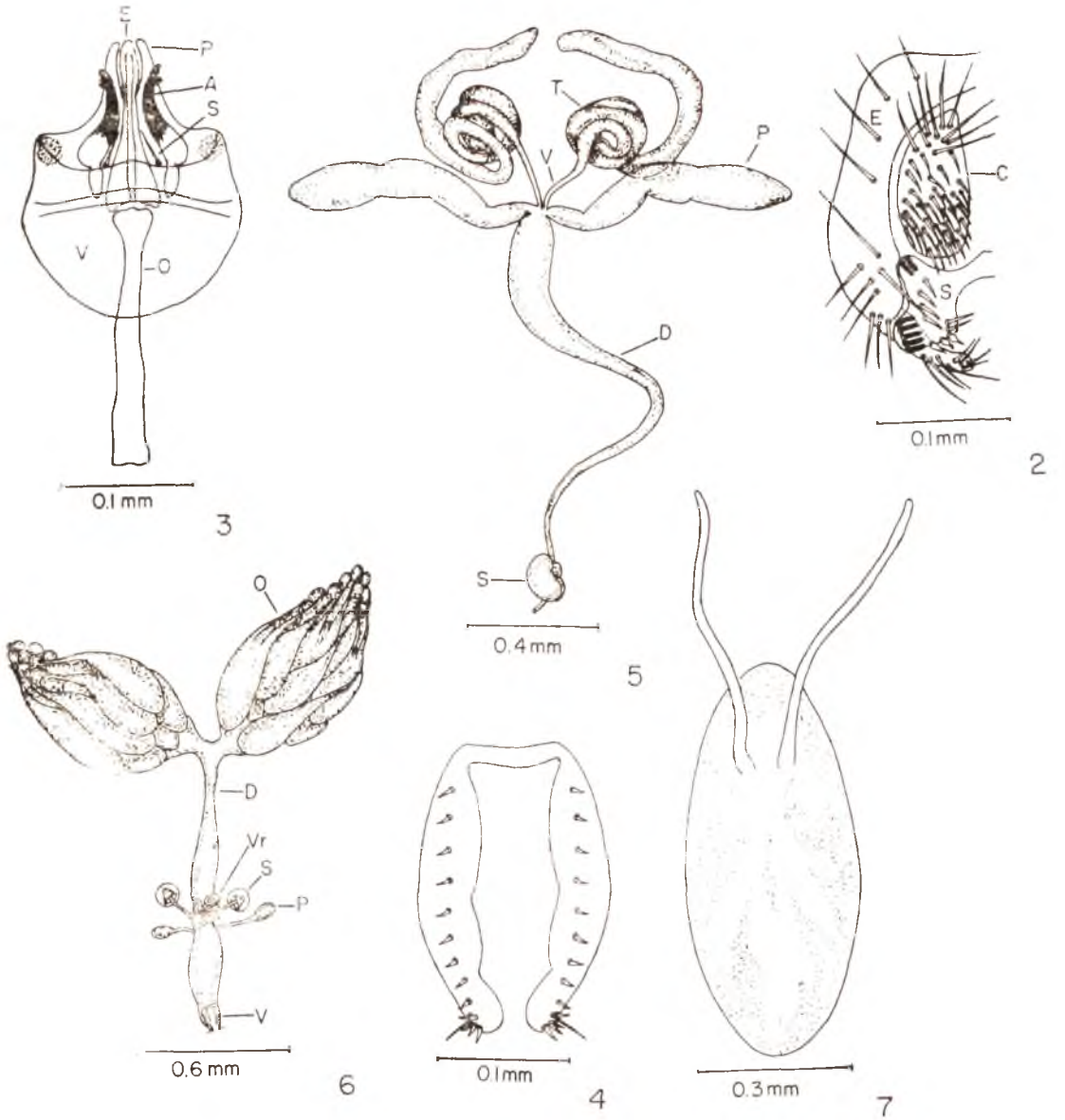

Fig. 2. Periphallic organs : C – Cerci, E – Epandrium, S – Surstylus; Fig. 3. Phallic organs : A – Anterior gonapophyses, E–Aedeages, O–Ejaculatory apodeme, P – Posterior gonapophyses, S–Submedian spine of novasternum, V–Ventral fragma; Fig. 4. Egg guide. Fig. 5. Male Reproductive organs : D – Anterior ejaculatory duct, P – Accessory gland, S–Ejaculatory bulb, T – Testes, V – Vas deferens; Fig. 6. Female Reproductive organs : D – Oviduct, O – Ovary. P – Paraovaria, S – Spermatheca. V – Egg guide. Vr – Ventral receptacle ; Fig. 7. Egg.

Distribution: India: Western Ghats : Karnataka.

Relationships and **remarks :** The nature of the banding pattern of abdominal tergites, egg with 2 filaments, presence of posterior pair of malpighian tubules which are free and the type of puparia warrants its inclusion in the subgenus *Sophophora*. The characters like yellowsh abdomen which is distally shiny black in males; presence of sex-comb; periphallic organs with well developed epandrium; surstylus with teeth (setigerous clasper); phallic organs with anterior and posterior gonapophyses; long coiled ventral receptalce and spiral testes qualify its inclusion in the *melanogaster* species group (Bock and Wheeler, 1972). Further, the sex-comb in short transverse rows of stout black bristles on the first 2 tarsal segments; periphallic organs with a surstylus possessing a ventrolatral comb of long rounded black teeth and a few black teeth dorsolaterally; phallic organs with large anterior and posterior gonapophyses, the anterior being apically black and pointed, and posterior having basal branches; and the presence of submedian spines on the caudal margin of novasternum permit its inclusion in the *takahashii* subgroup (Bock and Wheeler, 1972).

D. jagri sp. nov., resembles *D. giriensis* (Prakash and Sreerama Reddy, 1977) in general features of phallic organs and periphallic organs. However, the two species differ from one another in the number of sex-comb rows, number of teeth in the ventrolateral comb of primary surstylus and in the shape of the aedeagus. Further, the new species differs from other members of *takahashii* subgroup in having several sets of distinctly different teeth in the primary surstylus and possessing the lowest number of teeth (5–6) in the ventrolateral comb; arrangement of bristles on the cerci (long fine bristles above, cluster of small bristles below); number of sex-comb rows and teeth in each row and in the wing indices. The combination of these features in this species makes it distinctly different from other known members of *takahashii* subgroup, and therefore deserves the status of a new species.

The specific name, *Drosophila jagri*, is coined to denote the place, Jagra valley, from where it was collected for the first time.

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TWO NEW SPECIES AND THREE NEW RECORDS OF APHIDS (HOMOPTERA : APHIDIDAE) FROM SIKKIM, NORTH EAST INDIA

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(*Received 30 December 1977*)

Two new species, viz., *Eutrichosiphum* (*Eutrichosiphum*) *tapatii* and *Eutrichosiphum* (*Neoparatrichosiphum*) *betulae* are described from Sikkim, India.

(*Key words* : **two new species of *Eutrichosiphum***)

A systematic survey for the aphid fauna in Sikkim during 1973–75 reveals that the subfamily Greenideinae is well represented in the area. The present paper includes description of two new species, i.e., *Eutrichosiphum* (*Eutrichosiphum*) *tapatii* and *Eutrichosiphum* (*Neoparatrichosiphum*) *betulae*. Besides these, *Eutrichosiphum* (*Eutrichosiphum*) *arunachali* Basu, Ghosh and Raychaudhuri, *Eutrichosiphum* (*Eutrichosiphum*) *davidi* Raychaudhuri and *Eutrichosiphum* (*Eutrichosiphum*) *takahashii* Basu, Ghosh and Raychaudhuri are also recorded for the first time from the state. All the material are in the Entomology Laboratory, Department of Zoology, Calcutta University.

1. Eutrichosiphum (Eutrichosiphum) tapatii sp. nov. (Fig. 1)

Apterous viviparous feamale: Body about 1.72–2.01 mm long with 0.88–1.05 mm as maximum width. Head brown; dorsal cephalic hairs short to long and mostly with acute to acuminate apices. Antennae concolorous with head, 5-segmented and about 0.48–0.53 × body; flagellum gradually and more distinctly imbricated apicad; processus terminalis about 1.34 – 1.62 × the base of last antennal segment and about 0.37–0.43 × segment III, flagellar hairs mostly with acuminate apices and the longest one on segment III about 2.27–3.50 × basal diameter of the segment. Rostrum extends slightly beyond hindcoxae; ultimate rostral segment bluntish bearing 4–6 secondary hairs; segments 4 and 5 of rostrum about 1.17–1.35 × second joint of hindtarsus and segment 4 about 3.44–4.12 × segment 5. Abdominal dorsum pale medially and with brown to dark brown patches anteriorly, laterally and posteriorly; acuminate, short and long dorsal hairs having mostly acuminate apices occur intermingled and the longest one on anterior abdominal tergites about 2.27–3.80 × basal diameter of antennal segment III; tergites 7 and 8 with 6 and 2 hairs respectively, longest one on tergite 7 about 2.50–3.18 × basal diamter of antennal segment III and that on tergite 8 about 2.0–2.70 × the mentioned diameter. Siphunculi brown to dark brown, curved outwards, about 0.22–0.25 × body and about 3.88–5.33 × its maximum width, at base about 1.90–2.55 ×; at middle about 2–70–3.80 × and at apex 1.44–1.77 × the middle width of hindtibiae; hairs on siphunculi short to long with acuminate apices and the longest one about 2.0–2.50 × the basal diameter of the siphunculi. Cauda transversely semioval and with 6–8 hairs

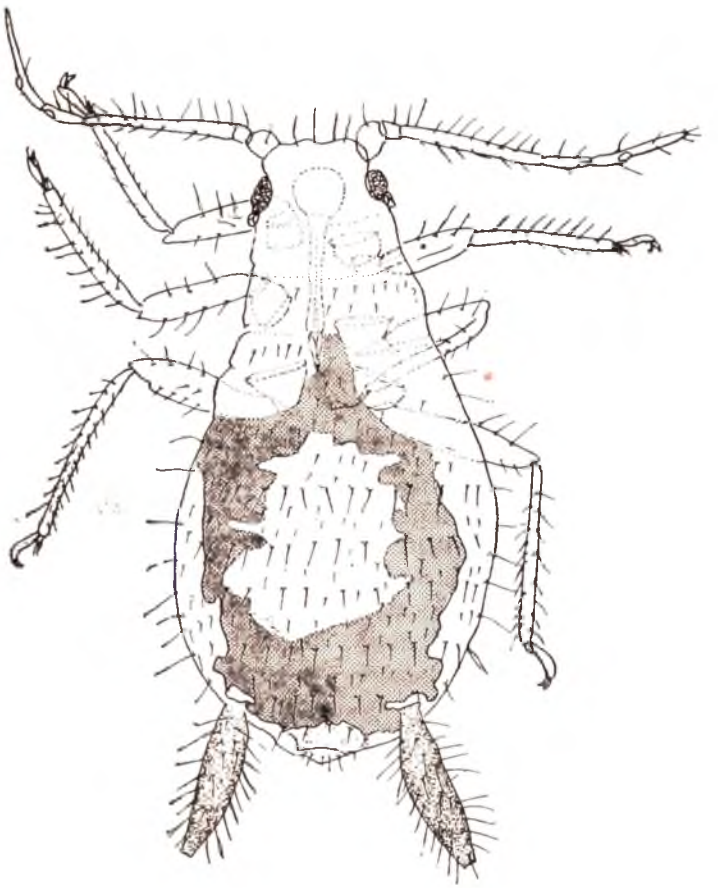

Fig. 1. *Eutrichosiphum* (*Eutrichosiphum*) *tapatii*, sp. nov : Apterous viviparous female.

Femora pale with indistinct spinulose striae on venter, tibiae sligtly darker than femora; F.T.C. 7, 7, 7.

Measurements of the holotype in mm : Length of body 1.79, width 0.88; antenna 0.95, segments III : IV : V 0.41 : 0.12 : (0.11 + 0.18); rostral segments 4 + 5 0.12; second joint of hindtarsus 0.10; siphunculus 0.44.

Holotype : Apterous viviparous ♀, INDIA SIKKIM : Sankland *c* 1000 m. 3.xi. 1974, from an unidentified plant, coll. P.K. Mondal; **Paratype :** 5 atpterous viviparous ♀ ♀ and 9 nymphs, collection data same as for the holotype.

Remark : This species approaches *Eutrichosiphum* (*Eutrichosiphum*) *makii* Raychaudhuri and Chatterjee (1974) by the pale median area on smooth abdominal dorsum but can easily be distinguished from the latter by shorter processus terminalis, pale and shorter siphunculi and in some other characters at measuremental level. This new species has been named after Miss Tapati Mandal, sister of the first author.

2. Eutrichosiphum (Neoparatrichosiphum) betulae sp. nov. (Fig. 2)

Apterous viviparous female : Body elongated, oval, pale brown about 2.89–3.28

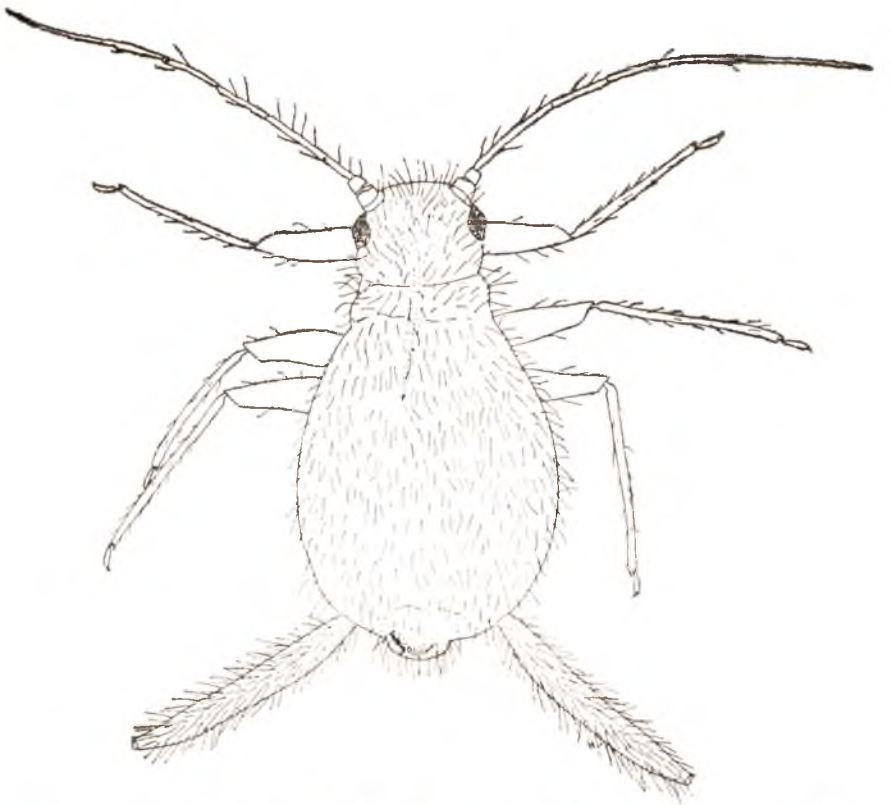

Fig. 2. *Eutrichosiphum* (*Neoparatrichosiphum*) *betulae*, sp. nov : Apterous viviparous female.

mm long with about 1.33–1.55 mm as maximum width. Head smooth and with long fine hairs. Antennae 6-segmented, about 0.78–0.85 × body; segments I, II, III concolorous with head and other segments brown; flagellum gradually distinctly imbricated apicad; segment III about 0.77–0.90 × processus terminalis with shorter hairs on inner margin and longer hairs with acute apices on outer margin, the longest one being about 4.0–4.61 × basal diameter of the segment; processus terminalis long, 2.77–3.16 × the base of segment VI; secondary rhinaria absent. Rostrum long, reaching second abdominal segment, segments 4 + 5 about 1.95 – 2.37 × second joint of hindtarsus and segment 4 about 5.33 – 5.71 × segment 5 and with 10–14 secondary hairs. Abdominal tergum smooth and with many long hairs having acuminate apices but a few of these with bifurcated or acute apices and the longest one on anterior abdominal tergites about 5.20–5.46 ×, on tergite 7 about 4.0–4.61 × and on tergite 8 about 4.66–5.35 × basal diameter of antennal segment III. Siphunculi about 0.45–0.51 × body and 7.14–11.0 × its maximum width, elongated, brown but slightly darker at apex, outwardly curved and covered with numerous long hairs, mostly having acute to acuminate apices, a few basal hairs with furcated apices, longest of these hairs being about 3.12–3.51 × the basal diameter of the siphunculi; width at base about 2.41–3.20 ×, at middle about 4.09–5.60 × at apex about 1.83–2.09 × middle width of hind-

tibiae. Cauda broadly oval with 8 long hairs. Femora pale and smooth, but tibiae slightly darker; F.T.C. 7, 7, 7.

Measurements of the holotype in mm : Length of body 3.03, width 1.45; antenna 2.51, segments III : IV : V : VI 0.61 : 0.30: 0.37 : (0.25+0.79); rostral segments 4 + 5 0.30, segment 4, 0.25, segment 5, 0.04; second joint of hindtarsus 0.14; siphunculus 1.38.

Holotype : Apterous viviparous ♀, INDIA : SIKKIM : Phodang *c* 1900 m, 19. x. 1975, from *Betula* sp. (Betulaceae), coll. P.K. Mondal, **Paratypes :** 9 apterous viviparous ♀ ♀ and 8 nymphs, collection data same as for the holotype.

Remark: This new species differs from its closest ally *raychaudhurii* Ghosh in following respects. Siphunculi 0.45–0.51 × body (in *raychaudhurii* 0.35–0.40 × body); siphunculi about 7.14–11.0 × its maximum width (in *raychaudhurii* 5.0–5.50 × its maximum width); processus terminalis 2.77–3.16 × base of last antennal segment (in *raychaudhurii* 1.80–2.0 × base of last antennal segment). Ghosh (1969) while erecting the species considered it under the genus *Paratrichosiphum* and subgenus (*Neoparatrichosiphum*) but according to Raychaudhuri, Raha and Raychaudhuri (1977) both *Paratrichosiphum* and *Neoparatrichosiphum* are now being considered as the subgenera under the genus *Eutrichosiphum*.

Acknowledgements :—The authors are thankful to the Head of the Department of Zoology, Calcutta University for Laboratory facilities and to Aphid Research Unit for necessary helps.

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Entomon, 1979 *Vol.* 4, *No.* 1, *pp.* 81 *to* 88

EXTERNAL MORPHOLOGY OF THE POPLAR DEFOLIATORS *PYGAERA FULGURITA* WLK. AND *P. CUPREATA* BUTL. (LEPIDOPTERA : NOTODONTIDAE)

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External morphology of pupae of *Pygaera fulgurita* and *P. cupreata* has been studied in detail. Form and colour of pupae, measurements of their length, width and weight have been recorded and morphology of head, thorax and abdomen described. Sexual dimorphism is very distinct in both the species. There is a significant difference in the length, width and weight of male and female pupae. The location and the shape of their genital openings are also different in the two sexes. The two species can be identified on the basis of shape of cremaster, distribution of punctures on the abdominal segments and presence or absence of folds around slit like anus.

(*Key words : Pygaera fulgurita, Pygaera Cupreata,* **poplar defoliators**)

External morphology of pupae of *Pyagaera* HUBNER (Syn. *Melalopha* HUBNER) is known from MOSHER (1916). ARRU (1965) has described the pupa of *P. anastomosis*. No systematic description of the pupae of Indian Notodontidae is available. The present paper is an attempt to describe pupae of *P. fulgurita* and *P. cupreata* and also to find out the distinguishing characters of male and female for an easy identification of the same for experimental studies on chemosterilization of males and also for the study of their sex pheromones.

Pygaera fulgurita WLK.

Form and colour

The last instar larva spins cocoon of larval hairs and pupates inside it mostly in a leaf-fold. The pupa is elongated and cylindrical in shape, rounded at the cephalic end and pointed at the posterior end. Freshly formed pupa is olive green ventrally, with reddish brown proleg scars on segments 3,4,5 and 6 and dorsally head and thorax olive green and abdominal segments reddish brown with dark brown scars (patches) on 1st and 8th segments. These scars are left by the black tubercles present on the dorsum of 1st and 8th abdominal segments of the larva. Pupa turns dark brown with age. Scars on the 1st and 8th abdominal segments also merge with the brown colour, only proleg scars of 5th and 6th abdominal segments are visible.

Head (Figs. 2, 3)

Antennae extend laterally, each tapers gradually to a pointed tip and the tips lie adjacent on the meson, caudad of the mesothoracic leg, widest at their proximal ends; fronto-clypeal suture not distinct: genae laterad of frons and clypeus and mesad of glazed eye; labrum distinct along its lateral, dorsal and frontal margin, the invaginations for the anterior arms of tentorium very distinct, associated with the lateral margin of the clypeus; pilifers, not present: eyes situated laterad of the genae and mesad of the antennae: labial palpi, small, triangu-

lar; maxillae, situated laterad of labial palpi one third or less than one third the length of wings; maxillary palpi not present.

Thorax (Figs. 1–4)

The segments of the thorax are distinct, visible only on the dorsal surface because ventral and lateral surfaces are covered by appendages; setae present; pronotal area transverse, anterior border convex, lateral angles obtusely rounded, posterior border sinuate; the femora of the prothoracic legs not exposed, lie adjacent to the maxillae at their proximal end; tibia and tarsi are the only segments which are visible. Mesonotum more than four times as long as pronotum, posterior margin deeply concave, median line is not distinct. Mesothoracic legs between the prothoracic legs and antennae, folded, coxae and femora are not visible, tibia and tarsi are the only segments which are visible. Mesothoracic wings conceal the wings of the metathorax. Out of 60 pupae studied, both the mesothoracic wings are separated medially by 2nd and 3rd pair of legs in ten pupae, while in remaining pupae they meet medially; only a portion of last metatarsal segment of metathoracic leg is visible. Prothoracic spiracle situated at the caudo-lateral angle of the pronotum. Metathorax as long as pronotum, anterior margin deeply concave, posterior margin sinuate. Tibia and tarsi of metathoracic legs not exposed for their entire length but are concealed by other appendages except at their distal end. On the ventral surface metathoracic wings are concealed by mesothoracic wings while on the dorsal surface a portion of these wings extending upto 3rd abdominal segment is visible.

Abdomen (Figs. 2–4)

Consists of 10 segments of which the last four segments i.e., 7–10 and 1st three i.e., 1–3 are fixed, i.e., they possess no power of

TABLE 1. Length, width and weight of male and female pupae (Mean±SE) of *P. fulgurita*.

Length (mm)					Width (mm)					Weight (g)				
Range		Average		Significance	Range		Average		Significance	Range		Average		Significance
Male	Female	Male	Female		♂	♀	♂	♀		♂	♀	♂	♀	
15.5	18	16.37	19.61	xxx	5.5	7	6.00	7.33	xxx	0.115	.167	.18	.28	xxx
to	to	±0.215	±0.227		to	to	±0.080	±0.080		to	to	±.007	±.027	
17	21.5				6.5	8.0				0.220	0.344			

xxx highly significant at 0.1% level.

independent motion, punctate on the proximal margin, punctures large and conspicuous in segments 3 to 7, setae visible on all segments except on the last two namely 9th and 10th. No furrow is present on the dorsum of the abdominal segments 8 and 9. Proleg scars in 5th and 6th segments distinct, found on the ventral surface near the meson. Anal opening slit like, situated on the summit of a moundlike elevation known as anal rise near the caudal margin of 10th segment. Spiracles, present on the abdominal segments 1 to 8, 1st pair covered over by wings. Cremaster (Fig. 5) stout, spine of about 1 mm in length, bifurcate, each half with four short spiny processes.

Measurement

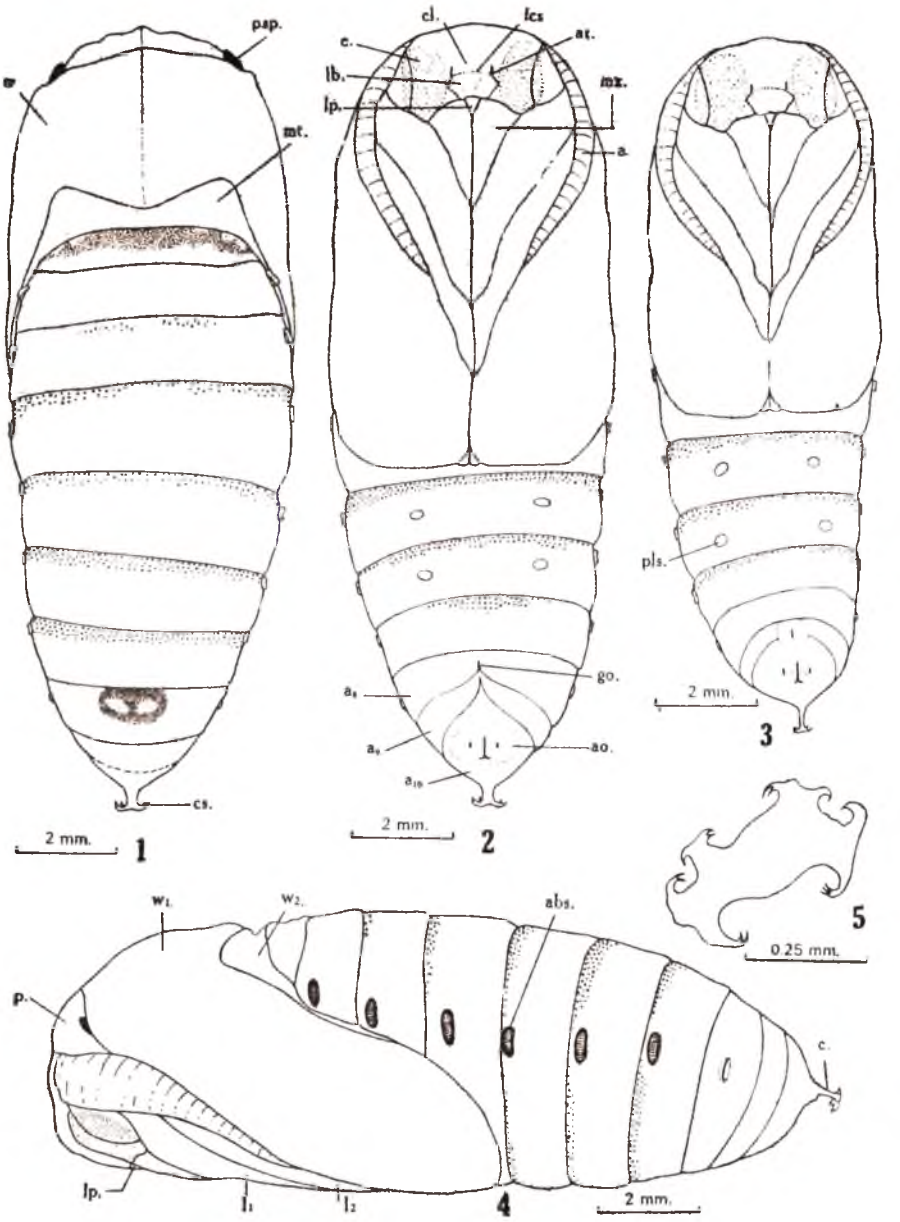
The average length, weight and width of the male and female pupae are given in Table–1. There is a significant difference between the average length, width and weight of the male and female pupae.

Sex dimorphism

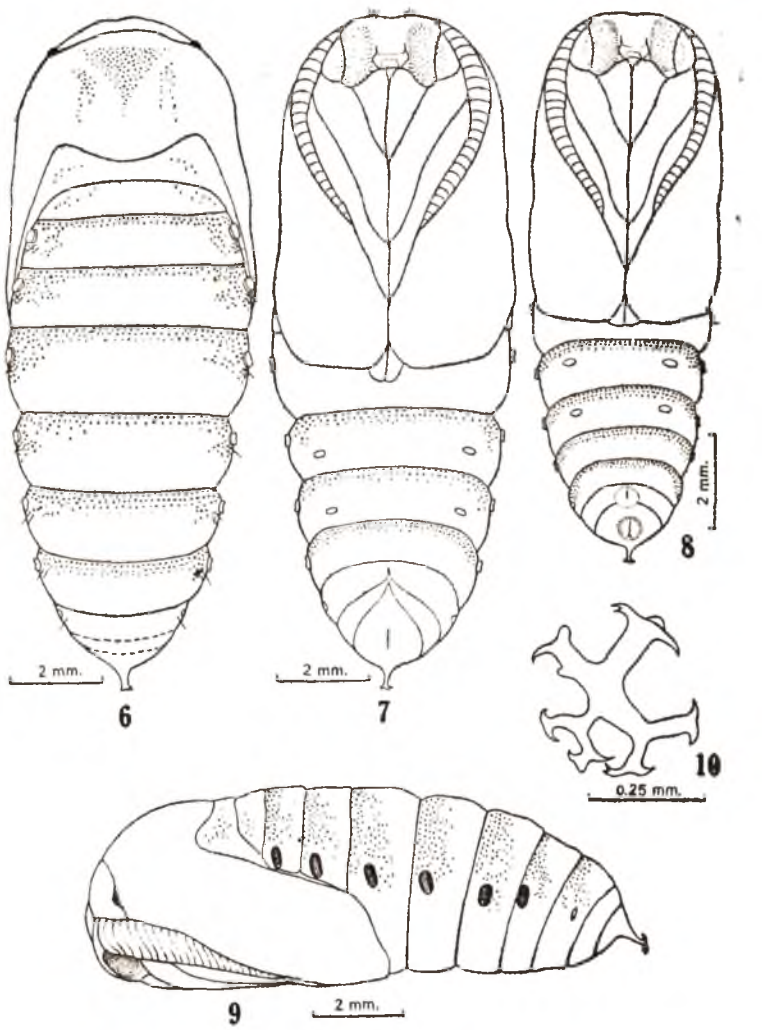
The male and female pupae have many characters (Table 2) on the basis of which they can be distinguished from one another. The most important distinguishing characters are shape and position of genital apertures.

TABLE 2. Distinguishing characters of male and female pupae of *P. fulgurita*.

Characters			Male	Female
Size:	Length:	Range	15.5–17 mm	18 to 21.5 mm
		Average	16.3 mm	19.1 mm
	Width:	Range	5.5 to 6.5 mm	7 to 8 mm
		Average	5.9 mm	7.4 mm
	Weight:	Range	0.115 to 0.220g	0.167 to 0.344 g
		Average	0.180 g	0.260 g
Genital opening			In 9th abdominal segment ventrally near the anal opening	In 9th abdominal segment; anal and genital openings are quite apart
Shape and size of genital opening			It is bordered by muscular elevations and is quite larger than female genital opening	Slit like and not bordered by muscular elevations
Number of segments behind mesothoracic wing ventrally upto genital openings			4 segments	3 segments
Median prolongation of 10th abdominal segment ventrally			not present	Median prolongation of 10th abdominal segment upto 8th segment which can be seen with naked eye



Figs. 1–5. External morphology of pupa of *Pygaera fulgurita* WLK: 1. Dorsal view;; 2. Ventral view of female; 3. Ventral view of male; 4. Lateral view; 5. Cremastral spine.



Figs. 6–10. External morphology of pupa of *P. cupreata* BUTL.: 6. Dorsal view; 7. Ventral view of female; 8. Ventral view of male; 9. Lateral view; 10. Cremastral spine.

ABBREVIATIONS

a_8–a_{10}. abdominal segments 8–10; a. antenna; abs. abdominal spiracle: ao. anal opening; at. invaginations for the anterior arms of the tentorium; cl. clypeus; c. cremaster; cs. cremastral setae; e. eye piece; g. o. genital opening; lb. labrum; l_1. prothoracic leg; l_2. mesothoracic leg; l_3. metathoracic leg; lcs. labro-clypeal suture; lp. labial palpi; ms. mesothorax; mt. metathorax; mx. maxilla; p. prothorax; psp. prothoracic spiracle; pls. proleg scars; w_1. mesothoracic wing; w_2. metathoracic wing.

Pygaera cupreata BUTL.

Form and colour

It is elongate, cylindrical in shape, rounded at cephalic end and pointed at the posterior end. Freshly formed pupa of *P. cupreata* is brownish with dorsal, yellow patches in posterior region, greenish brown dorsally in anterior region and ventrally pale green with brownish proleg scars turning brown in colour as time passes.

Head (Figs. 7, 8)

Antennae, widest at their proximal ends, taper gradually to a pointed tip and tips lie adjacement to the meson caudad of the mesothoracic legs. Fronto-clypeal and epicranial sutures not distinct, setae present on proximal margin of frons; genae, laterad of frons and clypeus, these can be distinguished from eyes in freshly formed pupa but not in old pupa. Labrum, distinct along its lateral and dorsal margins. The invaginations for the anterior arms of tentorium very distinct and associated with the lateral margin of clypeus. Eyes situated laterad of genae and mesad of antennae. Labial palpi, small triangular area just caudad of labrum; maxillae laterad of labial palpi one third or less than one third the length of wings.

Thorax (Figs. 6–9)

Setae present. Pronotal area transverse, anterior border convex, posterior sinuate. Prothoracic legs lie adjacent to the maxillae, meeting medially to the maxillae: Mesonotum, more than four times as long as pronotum, anterior margin sinuate, posterior margin deeply concave: Mesothoracic egs lie adjacent to the prothoracic legs, folded exactly in the same way as prothoracic legs meeting medially on the meson caudad of maxillae. Mesothoracic wings visible ventrally concealing wings of metathorax, in a few pupae these are overlapping each other but in most of the pupae these are meeting medially, reaching upto caudal margin of 4th abdominal segment in most of the pupae, in a few found reaching upto proximal margin or middle of this segment. Prothoracic spiracle situated at the caudo-lateral angles of pronotum just behind pronotal margin of metathorax, approximately as long as pronotum, anterior border deeply concave, posterior margin slightly convex with lateral margin obtusely rounded; a portion of metathoracic legs exposed medially behind the wings reaching middle of the 4th segments; a strip of metathoracic wings reaching upto 3rd abdominal segment dorsally, is visible while on ventral surface these are concealed by mesothoracic wings.

Abdomen (Figs. 6–9)

Segments 1–3 and 7–10 are fixed, segments 4, 5, 6, movable in both the sexes, punctate, puncutres present in segments 2 to 8 on their proximal margins but in female pupae these are absent ventrally in 8th segment; setae present. Proleg scars distinct, ventrolateral on segments 5th and 6th. Anal opening slit like. Spiracles, present in 1–8 segments. Cremaster (Fig. 10) stout, spine of about 1 mm in length, quadrifurcate, each branch further sub-divided with spiny processes.

Measurements

The average length and width of the male and female pupae are given in Table 3. There is a significant difference between the average length of male and female pupae.

Sex dimorphism

The male and female pupae have many characters (Table 4) on the basis of which they can be distinguished from one another.

TABLE 3. Length and width (Mean±S E) of pupae of *P. cupreata*.

Length (mm)					Width (mm)				
Range		Mean		Signi-ficance	Range		Mean		Signi-ficance
Male	Female	Male	Female		Male	Female	Male	Female	
10.5 to 15.5	12.0 to 16.0	13. 21 ±0.224	14. 13 ±0.218	xxx	4.5 to 6.0	4.5 to 6.0	5.04 ±0.099	5.21 ±0.065	N S

xxx highly significant at 0.1% level.
N S not significant.

TABLE 4. Distinguishing characters of male and female pupae of *P. cupreata*.

Characters	Male	Female
Length : Range	10.5 to 15.5 mm	12 to 16.00 mm
Average	13.21	14.13
Genital opening	In 9th abdominal segment	In 8th abdominal segment
Caudal margin of 8th and 9th abdominal segments	Not divided	Divided medially by genital opening
No. of segments behind mesothoracic wings ventrally upto genital opening	4 segments	3 segments
Position of punctures on 8th abdominal segment ventrally	Present	Absent

TABLE 5. Distinguishing characters of *P. fulgurita* and *P cupreata*.

Characters	*P. fulgurita*	*P. cupreata*
Size		
Length	Range 15.5 to 21.5 mm	Range 10.5 to 16 mm
Width	Range 5.5 to 8.0 mm	Range 4.5 to 6 mm
Punctures	Present on 3–7 abdominal segments	Present on 1–8 abdominal segments
Cremaster	Bifurcate each half with four short spiny processes	quadrifurcate, each branch further sub-divided with spiny processes
Anal opening	Slit like and surrounded by several prominent folds	Slit like but folds absent

The most important distinguishing characters are shape and size of genital apertures.

Distinguishing characters of P. fulgurita *and* P. cupreata

By and large the pupae of these two species resemble each other but they have certain characters (Table 5) which distinguish one from the other.

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Entomon, 1979, *Vol.* 4, *No.* 1, *pp.* 89 *to* 94

FEMALE REPRODUCTIVE SYSTEM AND GENITALIA OF GENUS *LEMA* (CRIOCERINAE : CHRYSOMELIDAE : COLEOPTERA)

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(Received 30 January 1978)

Female reproductive system and external genitalia of genus *Lema* have been described. Some significant taxonomic observations based on the morphology of the internal reproductive organs and the female genitalia have been recorded.

(*Key words* : **female reproductive system, external genitalia, *Lema*, taxonomy, morphology**)

INTRODUCTION

Very little work has been done on the female reproductive organs and external genitalia of chrysomelid beetles. There are stray descriptions by KHATIB (1946) on *Galerucella birmanica* JAC., VARMA (1954, 1955) on the spermatheca in Chrysomelidae, SAINI (1954) on the reproductive organs of genus *Aulacophora*, TEOTIA (1959) on *Psylloides brettinghami* BALY, ROBERTSON (1961) on ovariole numbers in Coleoptera, DATTA GUPTA & KUMAR (1963) on the female reproductive organs of some coleopterans, VARMA (1963) on *Galerucella birmanica* JAC., FURSCH (1965) on the spermatheca in Coccinellids, DAS (1966 a, b) on *Dicladispa armigera* OL., MENDOZA & PETERS (1968) on *Diabrotica undecipunctata* HOWARDII BARBER, ZAKHVATKIN (1970) on the evolution of the female reproductive system in Chrysomelidae, LEONARDI (1972) on the spermatheca of Alticinae, Chrysomelidae; SUZUKI (1975) on *Pseudodera xanthospila* BALY, SILFVERBERG (1971, 1973, 1974, 1975, 1976) on the Galerucinae genitalia.

The present work on the female reproductive system and external genitalia has been carried out to bring out the importance of the constituent organs in the field of insect taxonomy of this group.

MATERIALS AND METHODS

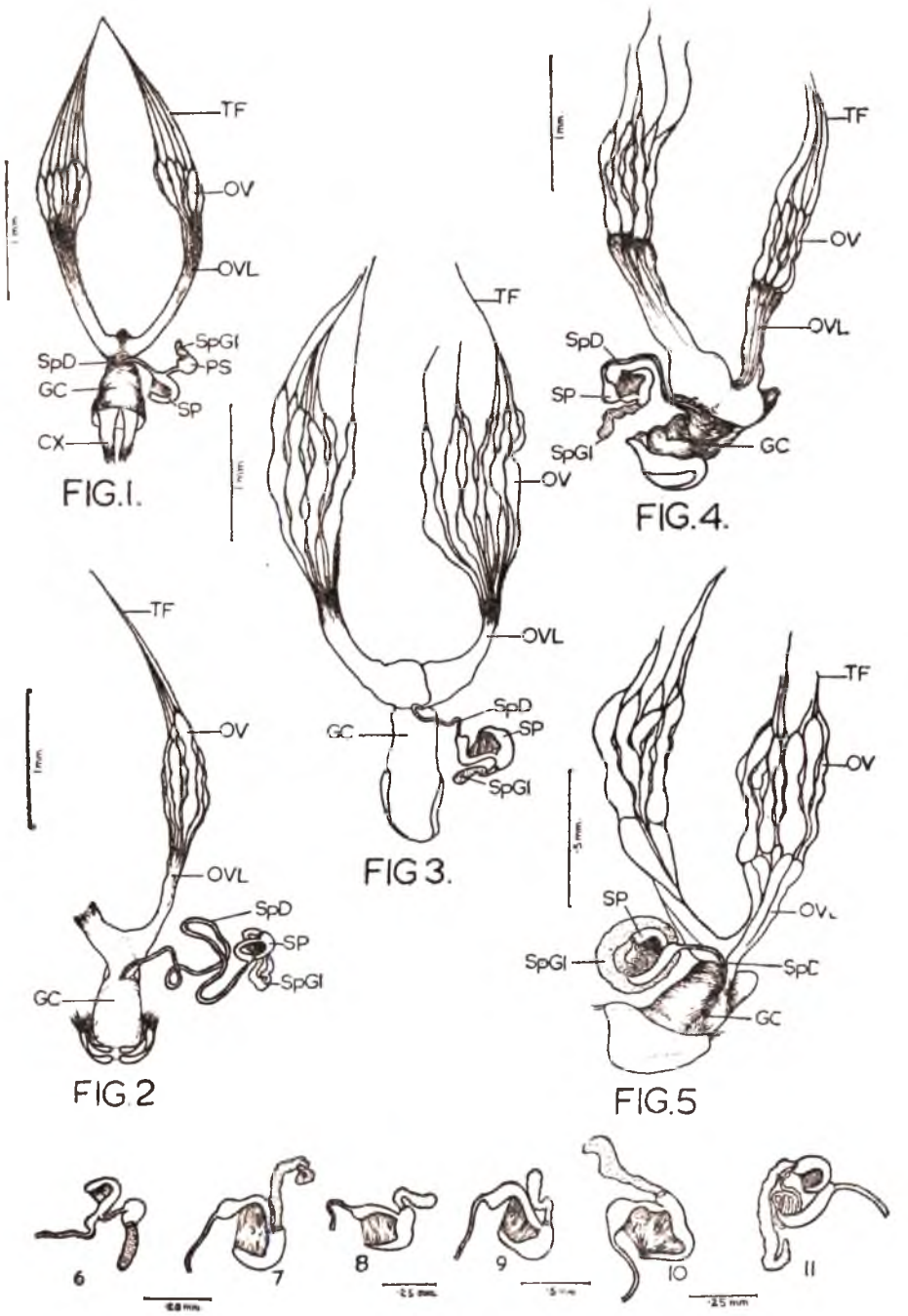
The specimens were collected by direct net sweeps from the grasses and the fields of groundnuts in the state of Punjab. The insects were preserved in Pample's fluid. The living insects were narcotized in ethyl acetate and dissected under a stereo-binocular. The external genitalia were cleared in 10% KOH solution and the diagrams were drawn with the help of a graph eye piece.

OBSERVATIONS

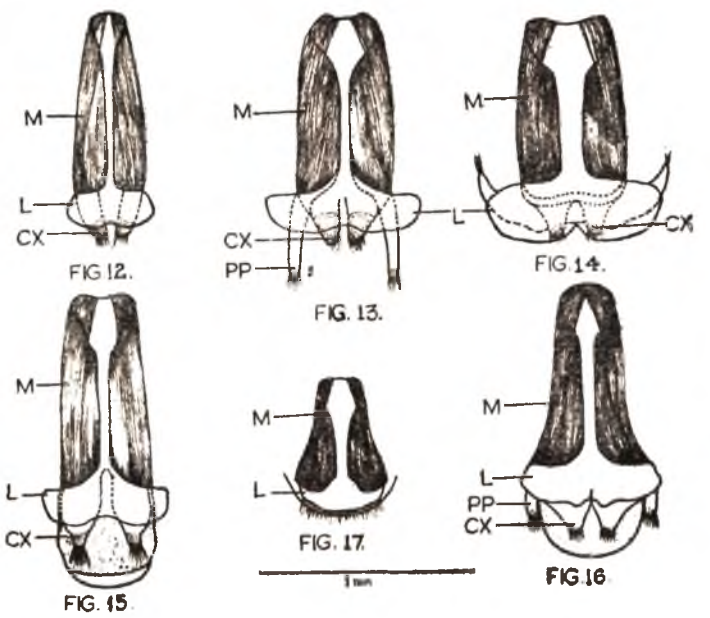
The female reproductive system in genus *Lema* consists of a pair of ovaries, two lateral oviducts, the median oviduct, the genital chamber and the spermatheca with its gland and duct.

Ovaries (Figs. 1–5).

The ovaries are located in between the second and the fourth abdominal segments lying embedded in fat bodies. Each ovary consists of a group of 7–9 cylindrical tubes or ovarioles (Table 1). The number of ovarioles is 7 in *Lema* sp., *Lema terminata* LACORDIARE, *Lema coromandeliana* F., *Lema downesi* BALY (Figs. 1,2,4,5), 9 in *Lema*



Figs. 1–5. Female reproductive system of: 1. *Lema* sp.; 2. *Lema terminata* LAC; 3. *Lema maheensis* JAC; 4. *Lema coromandeliana* FAB; 5. *Lema downesi* BALY; Figs. 6–11. Spermathecal complex of: 6. *Lema* sp; 7. *Lema terminata* LAC; 8. *Lema carinata* JAC; 9. *Lema maheensis* JAC; 10. *Lema coromandeliana* FAB; 11. *Lema downesi* BALY.



Figs. 12–17. Female genitalia of: 12. *Lema* sp; 13. *Lema terminata* LAC; 14. *Lema carinata* JAC; 15. *Lema maheensis* JAC; 16. *Lema coromandeliana* FAB; 17. *Lema downesi* BALY.

ABBREVIATIONS USED

CX—Coxite; GC—Genital Chamber; HT—Hemi-tergite; L—Ligula; M—Muscles; OV—Ovary; OVL—Lateral oviduct; OVN—Median oviduct; PP—Paraproct; PS—Pumping sac; SP—Spermatheca; SpD—Spermathecal duct; Sp. Gl.—Spermathecal gland; TF—Terminal filament.

varies from 7–9 (Table 1). The variations in number reported by ROBERTSON (1961) for Chrysomelidae range from 3–28. 12 ovarioles in *Galerucella birmanica* JACOBY by KHATIB (1946) and VARMA (1963). *Galerucella xanthomeleana* (=*Xanthogaleruca luteola*) possesses a range of 25–28 ovarioles. SAINI (1954) in genus *Aulacophora* and QURESHI et al. (1971) in *Aulacophora indica* GMEL. mentiond 28–30 and 43–59 ovarioles, respectively. SILFVERBERG (1976) counted 8–9 ovarioles in *Galerucella nymphaea* L.

In Chrysomelinae, WILLIAMS (1945) reported 20 or more ovarioles in *Leptinotarsa decemlineata* (SAY) and in *Expitrix* sp. In Criocerinae, GUPTA & RILEY (1967) while studying the reproductive organs of *Crioceris asparagi* L. showed the presence of 11–13 ovarioles. In Hispinae, DAS (1966b) mentioned 9 ovarioles in *Dicladispa armigera* OL.

In Alticinae, TEOTIA (1959) reported 13 ovarioles in *Psylloides brettinghami* BALY, SUZUKI (1975) has found 30–220 in *Pseudodera xanthospila* BALY. WALOFF & RICHARDS (1958) in *Phytodecta olivacea* FORSTER reported 10 ovarioles on each side, the number varying between 8–12. MENDOZA & PETERS (1968) studied *Diabrotica undecipunctata* HOWARDII BARBER and mentioned 50–60 ovarian follicles with an average of 56 ovarioles per lobe.

In genus *Lema*, the number of oocytes

maheensis JACOBY (Fig.3), thus 7 ovarioles constituting a feature of majority (SUZUKI, 1974).

The number of oocytes in each ovarian follicle varies from 2–3 in *Lema* sp. (Fig. 1), *Lema maheensis* JACOBY (Fig. 3), 2–4 in *Lema carinata* JACOBY, *Lema downesi* BALY (Fig. 5), 3–4 in *Lema coromandeliana* (Fig.4) and 3–5 in *Lema terminata* (Fig.2).

Each lateral oviduct is a comparatively long tube, measuring on an average from .013–.015 mm to .035–.04 mm in length and from .002–.004 to .008– .01 mm in breadth (Table 1). The two lateral oviducts unite to form the common median oviduct. It is a short and wide tube opening posteriorly by the gonopore into the anterior end of the genital chamber. Thus the chamber represents a wide, continuous, rectangular passage and opens to the exterior by the vulva between the coxites. A definite accessory gland is lacking.

Spermathecal Complex (Figs. 6 to 11)

This complex constitutes a chitinized anchor-shaped structure divisible into two parts, the basal two-thirds having a uniformly broad bow-shaped stem, while the posterior one-third is comma-shaped with a rounded head directly attached with the stem through the belly. There is a band of muscles in between the two parts of the spermatheca. The spermatheca measures on the average .007–.01 mm in length and .005–.007 mm in breadth (Table 1). The shape of spermatheca varies in different species. It is anchor–shaped with the posterior one-third modified into a chitinized pumping sac into which, in turn, opens the spermathecal gland (Figs. 1,6) while in *Lema terminata* (Figs. 2,7) and *Lema coromandeliana* (Fig. 10), the posterior one-third recipient of spermathecal duct is bulbous and spermathecal gland opens into the anterior two-thirds. In *Lema maheensis* JACOBY (Fig. 3,9) and *Lema carinata* (Fig. 8) the spermathecal duct arises from one side of the posterior portion of the spermathecal part. In *Lema downesi* BALY (Figs. 5,11), the condition is altogether different, the posterior one–third hook-like part recipient of spermathecal gland, communicates with two-thirds slightly arched portion through a convoluted tubular duct. The spermathecal gland measures on an average from 0.006–0.017 mm in length and from 0.0015–.004 mm in breadth.

External Genitalia (Figs. 12 to 19)

In the adult females there are seven visible abdominal segments. The female genitalia, which is constituted by the 8th, 9th and 10th abdominal segments, lie concealed beneath the 7th abdominal segment. The 8th tergite is drawn inside the body and is divided into two hemispherical plates called hemitergites; the 8th sternite is also located inside the body and forms a spade-like structure called the ligula having a less chitinized area near the apex. Ligula varies in shape and size from species to species, thus forming a character of taxonomic significance. The 9th sternite is entirely membranous and carries in the midventral region a pair of large, closely set, unjointed coxites bearing long spines at their terminal ends. The vulva is located in between the coxites. The styli are absent. The paraprocts which according to TANNER (1927) may be a part of the 9th tergite, are well-developed as more or less triangular sclerites and lie beneath and covered over by the coxites.

DISCUSSION

The female reproductive system in Criocerinae has not been studied in much detail. There are scattered contributions by some workers. The present studies reveal that the number of ovarian follicles

TABLE 1. Comparative data on reproductive system of *Lema*.

Name of the Species	Ovary		Oviduct		Genital chamber		Spermatheca		Sp. gland		Sp. Duct	
	No. of Ovar. foll.	No. of Ova in each foll.	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
Lema sp	7	2–3	0.022–0.024	.003–.004	.013–.015	.003–.008	.009	.006	.009–.011	.0015	.007–.009	.001
Lema terminata LAC.	7	3–5	0.022–0.025	.003–.004	.032	.01	.008	.007	.01–.012	.002–.004	.07–.08	.001–.0015
Lema maheensis JAC.	9	2–3	0. 03–0.032	.003–.005	.020–.025	.01	.008	.006	.007	.002	.01	.001
Lema carinata JAC.	7	2–4	0.035–0. 04	.008–.01	.025–.027	.021–.015	.01	.006	.015–.017	.002–.0025	.009	.001
Lema downesi BALY	7	2–4	0.013–0.015	.002–.004	.015–.017	.006–.008	.007	.006	.006–.008	.0015–.002	.006–.007	.001
Lema coromandeliana F.	7	3–4	0. 02–0.025	.005–.01	.020–.022	.011–.013	.01	.005	.008–.01	.003–.004	.025	.001

in each ovarioles varies from 2–5. In *Crioceris asparagi* L. (Criocerinae) and *Psylloides brettinghami* BALY (Alticinae), there are 2–3 oocytes.

In the genus *Lema*, the 8th abdominal sternite is greatly modified into a spade-like structure called Ligula. The 8th tergite forms two semi-circular plates called hemitergites. In genus *Lema*, the ligula and the two hemitergites form a tube rather tightly enclosing the outer parts of the rectum and vagina (Figs. 12–17). SILFVERBERG (1976) reported the same condition *Phyllobrotica quadrimaculata* L. QURESHI *et al.* (1971) do not mention any structure that could be called the ligula in *Aulacophora* but SILFVERBERG (1976) has reported in *Aulacophora foveicollis* LUC. Within Galerucinae, *Galerucella* is peculiar in lacking the ligula. In the closely related genus *Pyrrhalta* (not always kept separate from *Galerucella*), the ligula is well developed.

Thus, during the present investigations, it has been recorded that the shape and the size of the spermatheca, spermathecal gland and the length of the spermathecal duct; the shape of the ligula, and the genital chamber with its abdominal appendages like the paraprocts, the valvifers and the stylus constitute some of the major taxonomic characters in the female reproductive system. Besides this, the peculiarities in the shape, presence or the absence of the spermatheca if investigated in details, can be put to good use in the phylogenetic studies pertaining to the family Chrysomelidae.

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MOUTH PARTS OF *SPHYRACEPHALA HEARSEIANA* WESTWOOD (DIOPSIDAE : DIPTERA)[1]

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The mouth parts of *Sphyracephala hearseiana* WESTW. are typically of the muscoid type and one divisible into basiproboscis, mediproboscis and distiproboscis. The basiproboscis contains internally the cibarial pump and salivary pump whereas the mediproboscis contains the prepharyngeal food canal and the boat-shaped hypopharynx with the opening of the salivary duct at its distal end. A pair of labial palps are present dorsal to the junction of the mediproboscis and distiproboscis. The labial palps are being described here for the first time and is perhaps a primitive character. The labellar lobes are membranous and contains canaliculi or pseudotracheae opening into a prestomum.

(*Key words : Sphyracephala hearseiana, mouthparts*)

INTRODUCTION

The mouth parts or the proboscis of Diptera attracted the attention of morphologists from very early days. Major publications on the topic are by SUFFOLK (1869), MACLOSKIE (1880), LOWNE (1870–1895), HUNT (1896), HANSEN (1903), WESCHE (1908), STEPHENS & NEWSTEAD (1907), CRAGG (1912), PETERSON (1916), WHITEFIELD (1925), JOBLING (1926, 1928, 1936), GRAHAM-SMITH (1930), SNODGRASS (1944), NICHOLSON (1945), BLETCHLY (1952, 1954 & 1955), NAYAR (1965) and IPE (1968). Of these, the works of WESCHE (1908) and GRAHAM-SMITH (1930), both on the mouth parts of blow flies, and of SNODGRASS (1944) on the feeding apparatus of biting and sucking insects, are of outstanding nature. The present paper is one in a series on the detailed morphological study of the *Sphyracephala hearseiana* WESTW.

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MATERIALS AND METHODS

Techniques employed for the study of mouth parts are the same as described in earlier paper by KUMAR (1978).

RESULTS AND DISCUSSION

Proboscis

The organs of ingestion in *Sphyracephala hearseiana* are typically of the muscoid type comprising the proboscis projecting downwards as a free lobe from the oral fossa on the head capsule. The probocis is attached to the oral rim by a membranous area which remains folded when the proboscis is not extended. The mandibles are absent while the maxillae are represented only by a pair of unsegmented maxillary palps. The proboscis can be easily divided into the following three regions: (i) A large basal part, the basiproboscis or rostrum; (ii) The middle region or the mediproboscis or haustellum; (ii) The distal or terminal distiprobscis or labella.

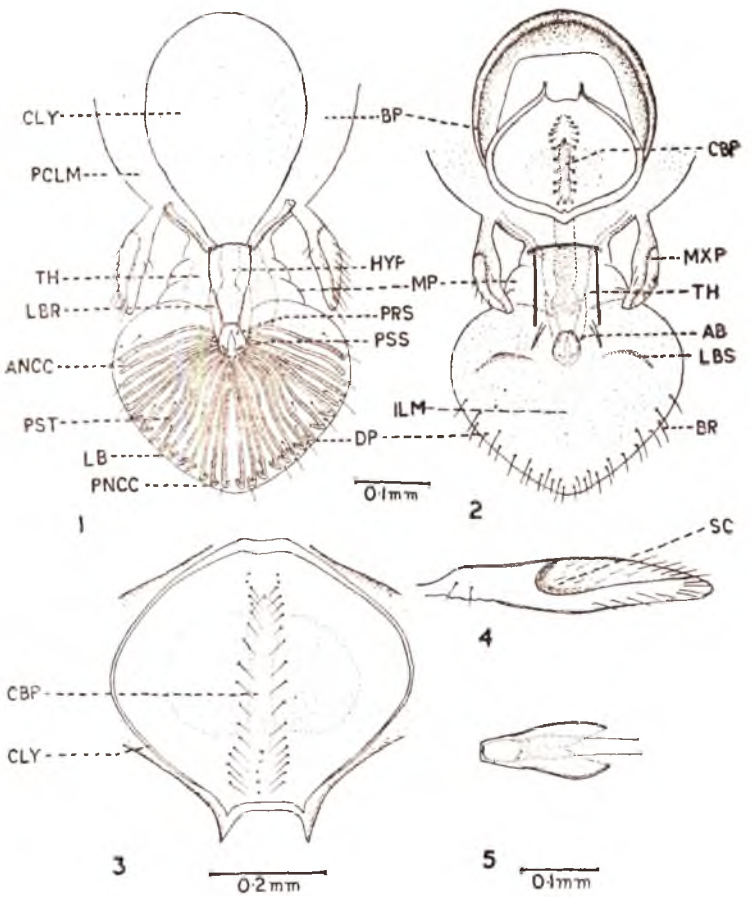

Fig. 1. Anterior view of the proboscis; Fig. 2. Posterior view of the proboscis; Fig. 3. Anterior view of the clypeus (Highly magnified); Fig. 4. Maxillary palp; Fig. 5. Labrum-epipharynx and hypopharynx.

Basiproboscis (Figs. 1 & 2)

It is the longest and conical basal portion of the proboscis and its proximal margin is attached to the "oral margin" or oral fossa by the periclypeal membrane (Fig. 1). This membrane is believed to represent the widened out epicranial 'suture' or sulcus in lower groups of insects. The entire basiproboscis is more or less membranous except for the horse-shoe shaped clypeal sclerite with its free terminal ends directed downwards. The clypeus is wide and better sclerotised towards its upper end and its free end tapers distally giving support to the rostral membrane. Antero-dorsal to the terminal ends of the clypeal arms arise a pair of long unsegmented maxillary palps (Figs. 1,2 & 4). The maxillary palp is nearly five times as long as thick, with a sensorium running from the middle of its length to its terminal end along its outer margin. The sensorium and the outer margin of the palp is fringed with numerous prominent setae and is covered all over with fine pubescence and bears groups of sensory papilla. It functions perhaps as an additional sense organ.

The clypeus was first recognised by PATTON & CRAGG (1913). GRAHAM-SMITH (1930) calls it the anterior arch of the fulcrum. PETERSON (1916) called this "torma" with the mistaken notion that it is derived from the lateral basal process of the labrum and most of the recent Dipterists followed him. CRAMPTON (1942) is of the view that this sclerite is formed by distinct anteclypeal sclerites such as those found in the termites, mole crickets and other orthopteroid insects. The attachment of the cibarial dilators on to it made SNODGRASS (1944) FERRIS (1950) NAYAR (1965) and IPE (1968) consider it as true clypeus.

Internally, the basiproboscis represents a complex structure which contains the food canal (Fig. 6) forming the so-called cibarial pump. The cibarial pump is an elongated chamber with a median ridge into which open proximally the food canal of the proboscis. The cibarial pump appears as a stirrup-shaped structure along with the clypeus and is generally called the fulcrum by morphologists. Laterally the cibarial plate extends as the lateral plates.

The pharyngeal pump or the cibarial pump is formed by the sclerotisation of the dorsal and ventral walls of the food canal. The dorsal wall forms the dorsal plate or the dorsal cibarial plate (Fig. 6) whereas the ventral wall forms the ventral cibarial plate. Medially the pharyngeal pump is narrow, confining the food canal while the lateral sclerotised extensions are known as the lateral plates. The cibarial dilator muscles extending from clypeus are attached medially and their contraction can dilate the lumen of the cibarium and these can function as an effective sucking pump. The lateral extension of these remains as the lateral plates. The ventral wall or the floor of cibarium remains as a sclerotised plate and devoid of any muscle attachments. Distally the ventral plate of the cibarium is produced into a cornus which articulates with the proximal margin of the hypo pharynx or labrum-epipharynx.

The cibarium and the associated structures are quite often referred to as fulcrum by Dipterists as the whole structure can be moved forward and backward with the protraction and retraction of the proboscis, the hinging portion being the periclypeal membrane. Some people refer to this as the "pharyngeal skeleton" and CRAMPTON (1942) called it as the "fulcral pump." PETERSON (1916) consideres that the distal region of the fulcrum is formed by the basal portions of the epipharynx and hypopharynx while its proximal portion is formed by the "Torma." BLETCHLY (1954) reports a fulcrum where the lateral plates are completely absent in *Empis livida* L. (Empididae: Diptera).

Below the fulcrum or cibarial pump runs the narrow salivary duct; it becomes bulbous to form salivary syringe or pump (Fig. 6) before opening at the base of the hypopharynx. This salivary syringe is operated by muscles which are inserted on the bulbous structure.

WESCHE (1908) considers these palpi as labial palps but PETERSON (1916) on the basis of his studies on the head capsule and mouth parts proved them to be maxillary palpi. On either side of the fulcrum there are present two sclerotised rodlike structures known as lateral apodemes.

The mediproboscis (Figs. 1 & 2)

It is the middle, cylindrical portion attached to the distal end of the rostrum and lies folded along the anterior surface of the rostrum when not in use. SNODGRASS (1944) considered this portion

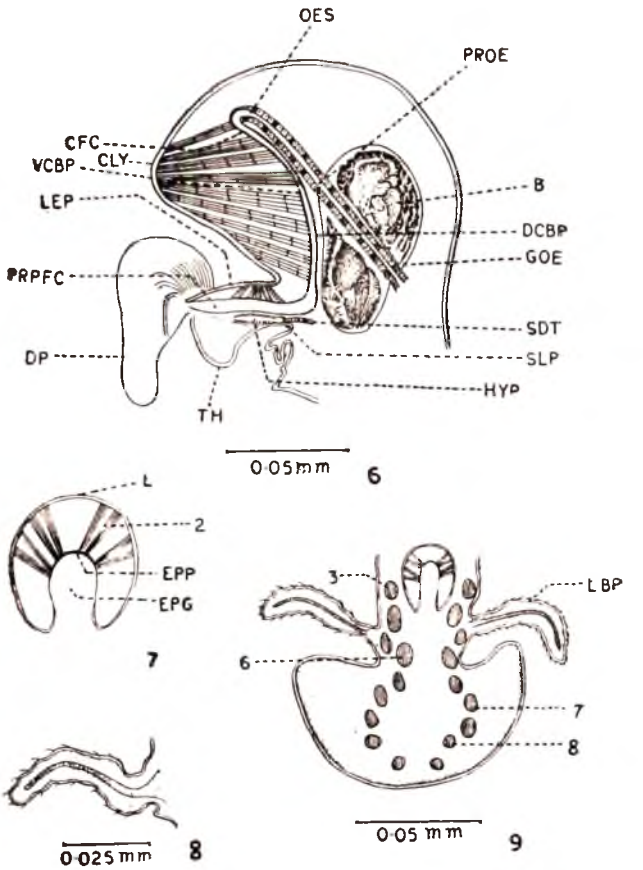

Fig. 6. Sagittal section of the head through the cibarium; Fig. 7. T. S. of the labrum-epipharynx; Fig. 8. T. S. of the labial palp; Fig. 9. T. S. of the theca.

ABBREVIATIONS USED

AB–Arched bar; ANCC–Anterior collecting channel; B–Brain; EP–Basiproboscis; BR–Bristle; CBP–Cibarium; CFC–Cibarial food canal; CLY–Clypeus; DCBP–Dorsal cibarial plate; DP–Distiproboscis; EPG–Epipharyngeal groove; EPP–Epipharyngeal portion; 2–Dilator of the labrum–epipharynx; 6–Dilator of the labial gutter; 7–Extensor of the labella; 8–Retractor of the labella; 3–Flexor of the labrum–epipharynx; GOE–Ganglionic vesophanous; HYP–Hypopharynx; ILM–Inter-labellar membrane; L–Labrum; LBP–Labial palp; LEP–Labrum–epipharynx; LBR–Labrum; LBS–Labellar sclerite; MP–Midiproboscis; MXP–Maxillary palp; OES–Oesophagus; PCLM–Periclypeal membrane; PNCC–Posterior collecting channel; PROE–Pre–ganglionic oesophagus; PRPFC–Pre–pharyngeal food canal; PRS–Prestomum; PSS–Prestomal spines; PST–Pseudotracheae; SC–Sensory cell; SDT–Salivary duct; SLP–Salivary pump; TH–Theca; VCBP–Ventral cibarial plate.

as representing the true proboscis of other insects. It is the longest portion of the proboscis in *S. hearseiana* measuring about 0.32 mm long. According to CARMPTON (1942) this portion wholly belongs to the labium and includes the prementum posteriorly while anteriorly it bears the labial gutter.

The labial or the posterior portion of the haustellum is formed by the heavily sclerotised prementum called by Dipterists as "theca" (Figs. 1,2 & 6). CRAMPTON (1942) prefers prementum to theca as the latter used to convey different meanings in different insects. The anterior surface is covered over by long flap-like labrum-epipharynx, attached to the distal end of the rostrum, bearing a pair of internal rods proximally, the lateral apodemal rods. The inner surface of the labrum-epipharynx bears two longitudinal ridges, which rest on the labium below, enclosing a food canal, the prepharyngeal food canal, in between them. The ventral side of the mediproboscis is supported by the theca.

The boat-shaped hypopharynx forms the floor of the prepharyngeal food canal (preoral food canal of NAYAR 1965), and is traversed longitudinally by the salivary canal. The salivary duct (Fig.6) enters the hypopharynx at its proxinal end. The labrum epipharynx, which forms the roof of the food canal, is broader basally and tapers towards the apex. GRAHAM-SMITH (1930) is non-committal in designating the true mouth opening but refers to this canal as the prepharyngeal food canal. In view of this the aperture in the labellar lobes with which the pre-pharyngeal food canal communicates terminally, should be called as pre-oral aperture or "prestomum" as aptly described by SNODGRASS (1944) and supported by the evidences available in *M. obtusa* (MALLOCH) (IPE, 1968) and in *Syrphus balteatus* (NAYAR, 1965), and not as the "oral apeture" of HEWITT (1907).

Labial palps:

A pair of membranous finger-like palps, the labial palps (Figs. 8 & 9) are seen on either side just above the junction of the mediproboscis with distiproboscis. Externally these palps are covered with numerous hairs. The function of these palps could not be ascertained. No such palps were reported in *Syrphus balteatus* by NAYAR (1965) or in *M. obtusa* by IPE (1968). The presence of labial palps are considered as a primitive character by many workers.

The distiproboscis (Figs. 1, 2 & 6)

The terminal part of the proboscis is variously named as oral sucker, oral disc, and labellum by many workers. The labellum is large, soft,membranous and is comprised of two oval lobes which are spread out flat to form a disc at the time of feeding. Anteriorly, the lobes are separated from one another by a deep cleft running from the margin of the lobes to the prestomum. Posteriorly they are joined by an interlabellar membrane (Fig. 2) which is continuous dorsally with the posterior membranous portion of the haustellum. The outer surface of each lobe is setaceous and is covered with a number of sensory bristles while the ventral surface is traversed by numerous canaliculi called the pseudotracheae (Fig. 1). The pseudotracheae are open canals and there are seventeen such canaliculi in each labellar lobe opening directly or indirectly into the prestomum. The anterior set of canaliculi or pseudotracheae run into a common anterior collecting channel which open at the anterior angle of the prestomum. Similarly the posterior set of pseudotracheae run into a common posterior collecting

channel which opens into the posterior border of the prestomum. The two central pseudotracheae open directly into the central area of the prestomum. Each canal is thickened along its wall by rib-like thickenings which serve to keep the canal open. Almost similar condition is reported by GRAHAM-SMITH (1930) in blow fly and NAYAR (1965) in in *Syrphus balteatus* and IPE (1968) in *M. obtusa*, although the number of canaliculi differ on either side of the prestomum. A pair of spinous processes, the prestomal spines, help in piercing the plant tissues for feeding. These correspond to the "prestomal teeth" or "oral teeth", characteristic of many blood sucking muscoid flies like *Musca crassirostsis*.

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BOOK REVIEW

EVOLUTION OF INSECT MIGRATION AND DIAPAUSE, Ed. by HUGH DINGLE, Springer–Verlag, New York, 1978.

Migration and diapause are two important strategies for escape in space and time. Different aspects of these have been discussed in various papers included in this book which has taken shape as an outgrowth of a Symposium entitled 'Evolution of escape in space and time' held at the XV International Congress of Entomology, Washington DC in August 1976. Three main sections included in this book are migration; diapause development and phenology; and migration, diapause and life histories. Some of the topics discussed in various papers are, Hormonal control of insect migratory behaviour, Evolution and phenological stratagies in insects; variability in diapause attributes of insects and mites; Migration, diapause and direct development of alternative life histories in a seed bug; Wing dimorphism and diapause in *Gerris;* and Migration and diapause in tropical, temperate and island milkweed bugs.

In the paper on hormonal control of migratory behaviour, RANKLIN deals with the role of hormones, especially juvenile hormone, in migratory physiology. Migration might result from a deficiency of juvenile hormone because this hormone was known to stimulate reproduction which in turn terminated long distance flight.

Diapause has two broad roles to play in the insect life histories. It permits escape in time, but it also interacts with development, MASKI, in his paper makes use of the unique features of the Japanese Islands extending from cold temperate to subtropical regions to study latitudinal influence on size and voltinism pattern in crickets. In another paper, HOY reviews the work on both inter and intra population variation in diapause and associated traits.

The last section of this book contains three papers dealing with both migration and diapause as integral parts of the life history strategies. In his paper, SOLBRECK first makes the point that migration and diapause are as important parts of life histories as mortality, development and birth. In the second paper in this section, VEPSALAINEN compares ten species of European water striders with respect to life histories invovling migration and diapause. In DINGLE's paper, he compares migration and diapause strategies in species and population of milkweed bug occurring in both temperate and tropical areas and on islands.

This book, produced under the head of 'Proceedings in life Sciences' is an excellent addition to the literature on diapause and migration and is dedicated to Professor JOHN S. KENNEDY F.R.S.

G.K. KARNAVAR

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